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OF

Department of Geology and Natural Resources

INDIANA

EDWARD BARRETT
State Geologist

1915

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HOMER L. COOK,
Secretary of State

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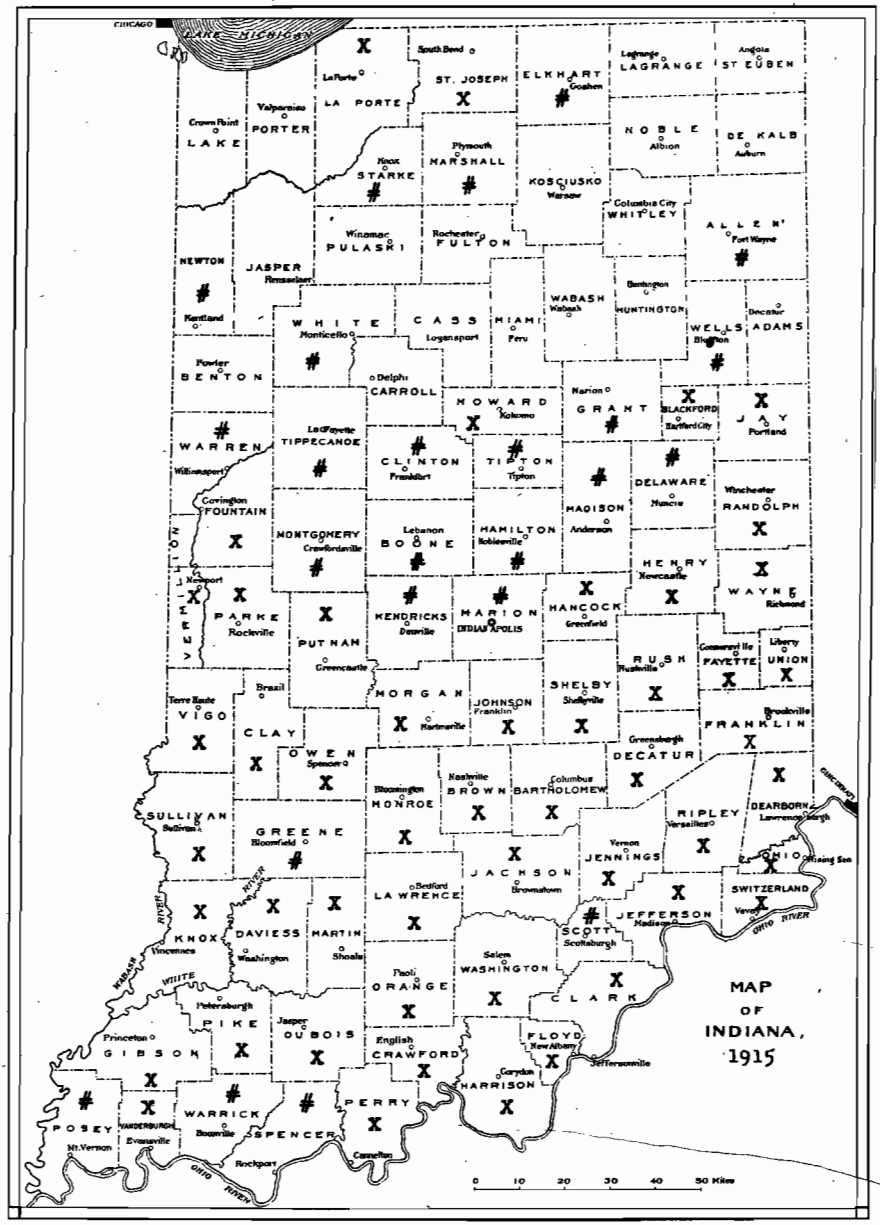


Map showing counties in which Soil survey has been made.
Counties surveyed by Indiana Department of Geology marked X.
Counties surveyed in co-operation with U. S. Bureau marked #.

EDWARD BARRETT, State Geologist.

STATE OF INDIANA.

DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND., August, 2, 1916.

Samuel M. Ralston, Governor of Indiana:

MY DEAR SIR—In accordance with the law governing the Department of Geology and Natural Resources of the State of Indiana, I submit to you the manuscript of the Fortieth Annual Report of said Department. For the fourth year the co-operative soil Survey of the State by counties has been conducted with the United States Bureau of Soils of Washington, D. C. This survey has been productive of much good to the agricultural and business interests of the State.

The submission of this report was delayed several months awaiting the report of inspection of the Soils Correlating Committee of the United States Bureau. Owing to the volume of work before it, this committee could not complete its work on the Indiana soils until a few days ago. Through the courtesy of Milton Whitney, Chief of the Bureau of Soils, the work was hurried on to completion, and our farmers will get the benefit this year of the work done in 1915 under the co-operative contract.

A review of the lines of work pursued by the Department for 1915 will be found in the introduction to this volume.

With the hope that the manuscript herewith submitted will meet your approval, and that the State Printing Board will order its early publication, I am,

Very respectfully,

EDWARD BARRETT,
State Geologist

INTRODUCTION.

By Edward Barrett, State Geologist.

It is contemplated in the law governing the Department of Geology and Natural Resources of the State of Indiana, that the State Geologist shall issue an Annual Report covering in as much detail as possible his surveys of as many of the natural raw materials of the State as he and his assistants can investigate in a calendar year.

The principal natural resources of Indiana are Coal, Stone, Shale, Clay, Oil, Gas, Water and Soils.

It is the purpose of the Department to gather and publish information on these resources each year. One of these is made the major line of investigation and others the secondary lines. The State Geologist has seen fit to select the Soils of the State for the heavier line of work, and upon which to spend the bulk of the annual appropriation of the Department. In the investigation of Soils the main problems to be worked out are geologic origin, nature of top and subsoils, topography, natural drainage, texture, mineral plant foods, amount of humus, and classification as to types.

The investigations do not include, except incidentally, cultural methods for crops. This phase of the work is left to the experimental, and extension work of Purdue University at Lafayette. With a view to secure for the farmers of the State the best information that can be gotten regarding their Soils under the above heads, the co-operative agreement between the Department of Geology of Indiana, and the United States Bureau of Soils, Washington, D. C., was continued in 1915 and 1916. Under this agreement the United States Bureau furnishes one expert soil man for each one furnished by the State of Indiana. The funds at the disposal of the State Geologist enabled him to request three soil experts from the United States Bureau, and to work with these three Indiana men. The United States Bureau paid all salaries and expenes of its men, and the Indiana Department of Geology paid salaries and certain expenses of its field men, not including any living expenses.

Three areas were selected jointly by Milton Whitney, Chief

of United States Bureau of Soils, and the State Geologist of Indiana, and included Wells, Grant and White counties. Later Starke county was added.

The work in Wells county was in charge of W. E. Tharp of the United States Bureau, and W. E. Wiley of the Indiana Department of Geology. These men went carefully over the county section at a time, and there were few farms, if any, that were not traversed.

One of the best map makers and soil experts of the United States Bureau is L. A. Hurst, who, with Phillip Middleton of the Indiana Department of Geology, made a detailed survey of the Soils of Grant county.

The work in White county was in charge of T. M. Bushnell of the United States Bureau and C. P. Erni of the Department of Geology. These men made a studious survey of the Soils of that county, and are to be commended for their energetic work.

E. J. Grimes who has had experience with the United States Bureau by agreement between Dr. Whitney and the State Geologist of Indiana, was assigned to Starke County. Mr. Grimes had as his assistant Wendell Barrett. The sands, marshes, mucks, and peats of Starke county presented many difficult problems to these men, but the Soil types and descriptions were worked out in a thoroughly satisfactory manner.

The Soils of Fountain county were worked out by C. H. Orahood who had spent a part of the seasons of 1914 and 1915 on them. Mr. Orahood's report is brief, though the Soil types are worked out in considerable detail on the map of the county. For descriptions of types found, the reader is referred to the same types in Montgomery and Parke counties.

Since two-thirds to three-fourths of Indiana are covered with glacial drift, and since the majority of our Soil types and the best of our Soils are glacial Soils, the State Geologist believes that knowledge of the Glacial Period in Indiana should be given from every possible angle. To this end he secured the services of Harry Warren Wood, a graduate student in Geology, to prepare a paper on "The History of Indiana during the Glacial Period." The paper is published in connection with our Soil investigations, that students of Soils may get a wider comprehension of our Glacial Soils and our Glacial Period.

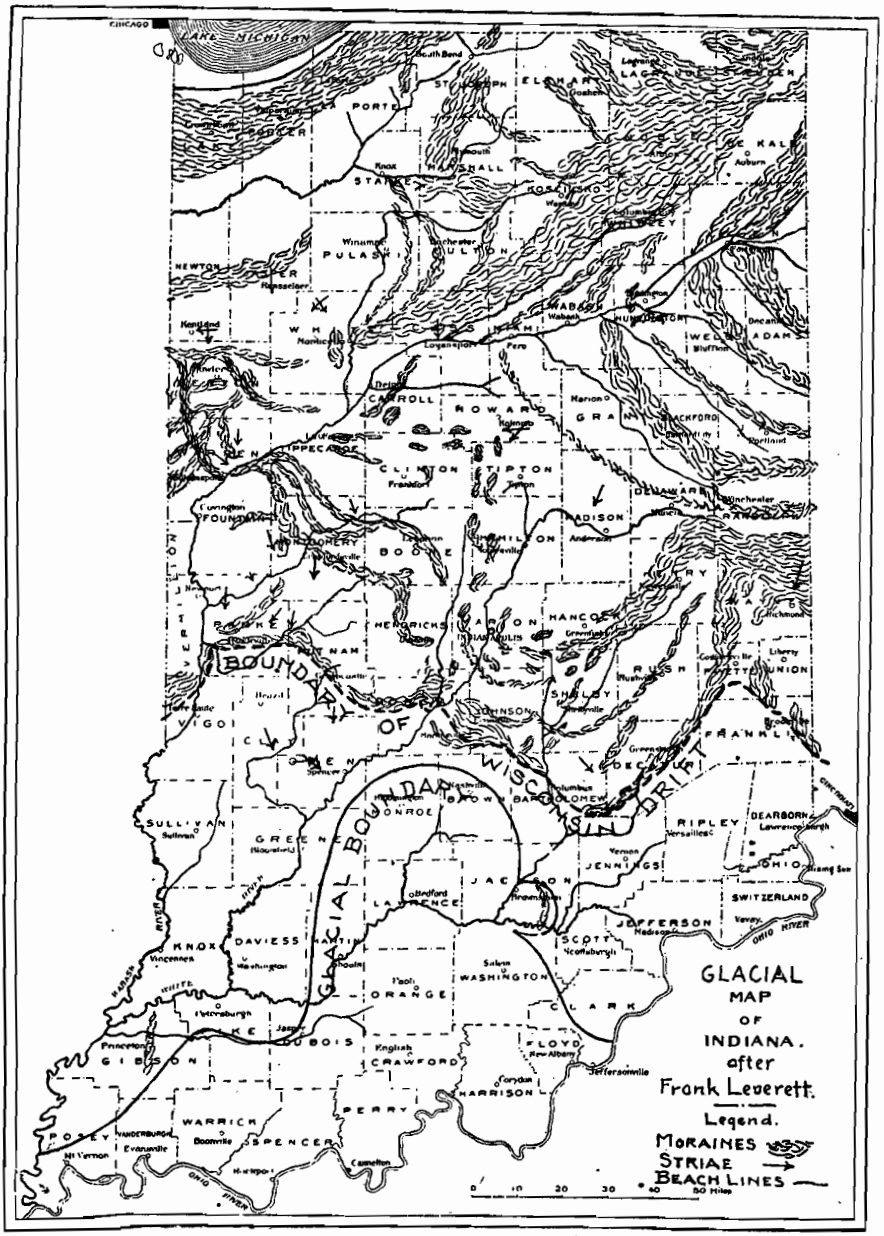
The State Geologist was fortunate in securing the services of Dr. A. J. Bigney, President of Moores Hill College; Dr. Glen Culbertson, of the Department of Zoology and Geology, Hanover

College; and Prof. W. B. Van Gorder, Superintendent of Schools, Lyons, Indiana; to prepare reports on the geology and resources of their respective counties, Dearborn, Jefferson and Greene. These reports are included in the present volume.

The Fortieth Annual Report closes with the report of the State Supervisor of Natural Gas, Floyd E. Wright, who gives a review of oil and gas conditions and prospects in Indiana for the calendar year of 1915.

Much of the time of the State Geologist for the past year was spent in delivering lectures on the State Park Movement. More than fifty illustrated lectures were given in different parts of the State, the purpose being to arouse interest in the beautiful natural scenery which abounds in the State. The State Geologist, also, gave lectures on good roads and soil problems.

The correspondence of the Department was unusually heavy during the past year, taking much of the time of the State Geologist in answering inquiries pertaining to the work of the year.


CHICAGO
LAKE MICHIGAN
BOUNDARY OF WISCONSIN DRIFT
GLACIAL BOUNDARY
GLACIAL MAP OF INDIANA. after Frank Leverett.
Legend.
MORAINES
STRIAE
BEACH LINES
0 10 20 30 40 50 Miles

The History of Indiana During the Glacial Period.

CHAPTER I.

PREGLACIAL INDIANA.

To reconstruct the history of Indiana during the glacial period we must first glance at the INDIANA of late Tertiary times.

Newsom—Proc. Ind. Acad. Sc. 1897. pp. 250-3.

The *general topography* of the state would have shown us various physiographic provinces distinguished from one and another by characteristics.

Leverett—U. S. G. S. Mon. No. 41, p. 77.

The southeast section we might have called the *Cincinnati Island.* The soil of the hills and valleys was underlain by limestones and shales of the Ordivician and Silurian age and due to a Paleozoic uplift this province stood higher than the regions to the west and northwest of it.

Note—In this region at the headwaters of the White and Whitewater Rivers in Randolph and Wayne counties, we still find the highest elevations in the state.

To the west of the Cincinnati Island is a broad north and south valley, which at first glance might seem the valley of a mighty glacier draining stream, but which closer investigation shows is a valley formed by many subaerial degradation agencies in the soft underlying shales of Devonian age. This region with next to be mentioned we might call the Devonian Valley.

Note—Newsom calls this the Eastern Lowland, a term which does not describe it clearly enough it seems.

Proc. Ind. Acad. Sc. 1897, pp. 250-3.
Leverett, No. 41, p. 76.

Running southwest across the central part of the state, just north of the *Cincinnati Island,* was another wide valley, 50 miles or more in breadth. This valley included most of north eastern Indiana up to where the Mississippi limestones began to outcrop in northeast Indiana and Benton and Fulton counties. The soil of this *Northern Devonian Valley,* as we might name it, was under-

lain principally by shales of the Devonian age, as in the case of the previous valley, with which it communicated on the south.

The western boundary of the Devonian Valley was a distinct escarpment of sandstone knobs of Mississippian age. West of these was the *Western Upland* which the streams were reducing to a base level by carving out their valleys in the Mississippian and lower Pennsylvanian limestones, shales and sandstones. This upland was limited in the north by the Northern Devonian Valley, although there was a remnant of it found in a water divide extending southwest and northeast in Benton County.

From the Western Upland and extending over into Illinois, was the *Western Lowland*, gradually sloping to the west. This had been cut out of the shales ofthe Upper Pennsylvania age.

Leverett, U. S. G. S. Mon. No. 38, p. 460.

This sketch of Pre-pleistocene Indiana, in the region covered by the glaciers, is only a reconstruction, due to the fact that most of the bedrock of the state is covered by 25 to 300 feet of glacial drift which hides the original topography.

General Lines of Drainage.

Since we have reconstructed the various physiographic regions of late Pliocene Indiana, let us get a general idea of the drainage of those days.

The drainage lines of the driftless region can be fairly easily located for Pliocene times. But when we remember that with the exception of the lower courses of the Wabash, White and Ohio Rivers, most of the other drainage lies on the glacial deposits, 25 to 300 feet thick, over the old pre-glacial courses, we can see the difficulty in trying to locate pre-glacial lines of drainage.

However, from well borings, we have traced the courses of some pre-glacial streams, and have determined the dip of the bedrock, and from these data we can get a general idea of the drainage of those days before the coming of the glaciers.

Leverett, No. 38, pp. 529-30.

The Northern Devonian Valley with its dip of 20 feet to the mile, must have had a pre-glacial Wabash running down its axis, we find its continuation, in a valley from about Lafayette south, and certainly from Covington south. At Terre Haute the present Wabash River is flowing over 100 feet of glacial gravel while the pre-glacial bluffs show in each valley face 5 miles apart. The head of the pre-glacial Wabash may have been up in Lake Mich-

igan but more likely it wandered down the steeper northwest, dipping limestones of the Cincinnati Island where a pre-glacial valley has been traced under the glacial drift by well logs, from Shelby County, Ohio, to Blackford County, Indiana. This pre-glacial Wabash was a larger stream than its present successor as shown by the width of its valley, which the present stream has not cleared out much above Terre Haute in its meanderings. After making a great bend above Covington it swung to the south down the Western Lowland where its valley widened to 15 miles at its junction with the Ohio River.

Leverett—No. 38, pp. 532-3.

Joining the Wabash River near its mouth is the White River, which from Worthington southwest meanders around in its pre-glacial valley, across the Western Lowlands. From Worthington northeast to Martinsville the West White River lies in its pre-glacial valley in a number of places. From Martinsville its course is so drift covered that it is at present impossible to say just what its pre-glacial course was. However, judging from the size of its pre-glacial valley below Martinsville, it must have headed above Indianapolis on the Cincinnati Island and flowed down the Devonian Valley, through the Knobstone escarpment, across the Western Upland to the Western Lowland. This course must have been carved out before the slow Tertiary uplift. The course above Martinsville will have to be shown by well logs, to the bedrock.

Note—A study of the well logs in Indianapolis would show something about the rock surface and probably determine whether the pre-glacial White River passed through there.

The greater part of the course of East White River was not affected to a great extent by the glacial drift and an analogy it shows something of the pre-glacial course of its neighbor, the West White River. With its tributaries, the Muscatatuck, the Flat Rock, etc., it heads up on the Cincinnati Island and wanders down the Devonian Valley, showing considerable reluctance to crossing the Knobstone escarpment. Then it gets across the Western Upland fairly quickly and joins the West White River down in the Western Lowland. As I have said above there is little drift in this river's valley and so a study of its course would show many of the characteristics of a pre-glacial stream.

Note—Proc. Ind. Acad. Sc. 1901, pp. 222-237. A study of Beanblossom Creek valley made some years since by Profs. Marstera, Cumings and Beede is valuable on this point.

Leverett, No. 38, pp. 97-101; 532.

On the western edge of the Western Upland three northward flowing streams joined the East White River in valleys which later were covered with glacial lucustrine deposits. These we will speak of later as Lake Patoka.

Leverett, No. 41, pp. 185; 323-4.

Flowing down the strike of the limestone beds of the Cincinnati Island was a stream heading about in its present place and finally emptying into a pre-glacial Ohio. The pre-glacial Whitewater valley must have been about the size of the present valley, as shown by well borings and was at least 100 feet below the present drift, which covers the valley floor, the tributary valleys and some of the slopes.

Leverett, No. 41, pp. 109-111.

Heading above Cincinnati and flowing through much of it present valley was a smaller Ohio. This valley was old as a trip from Vevay to Louisville will show, the bluffs in most cases standing quite a distance back from the river valley with their slopes soil covered. In Indiana, this pre-glacial Ohio came the dip of the Cincinnati Island uplift, wandered through the Devonian Valley which is narrow from east to west here, crossed the Western Upland in a southwest direction and was finally joined by the pre-glacial Wabash in the Western lowlands.

The upland of the Mississippian limestones in Benton County and east, which here formed the northern Devonian valley's northwest boundary, must have been a pre-glacial water divide. On the northwest side must have headed streams flowing into the Illinois River. However, as the drift is thick here and well borings are not numerous in the old lake Kankakee bottoms, we have not determined the course of any pre-glacial stream here.

Conclusion.

The main lines of pre-glacial drainage seem to have been, (1) down the northern Devonian valley and the western lowland, through a pre-glacial Wabash; (2) across the various physiographic provinces of Indiana through a pre-glacial Ohio; (3) midway between these a pre-glacial White River across the provinces.

The General Surface.

In an attempt to reconstruct the general surface of Indiana, before the coming of the Pleistocene glaciers, we would be helped much be recalling the general surface of the present driftless region of Indiana.

A trip through southwestern Indiana shows even an amateur observer, certain general characteristics which are observable over quite an extensive area. One of these which is quite common is the fact that the hill slopes are usually covered with a thin mantel of residual soil. Erosion here is at a maximum for the state. Another fact observable almost anywhere is that the valley bottoms are filled with alluvium brought down from higher levels.

Going across the various physiographic regions from east to west, one finds himself in a succession of narrow and wide valleys. A little investigation shows that this is determined by the kind of rock underlying the surface. The same kind of rock always produces the same kind of valleys.

The strike of the rock outcrops is generally north and south. The major streams seem to follow these strike lines, whi.e the minor streams come in at right angles to the strike, following the dip to the southwest.

In the upper courses of many of the streams we find clean, rock-ribbed valleys, showing the youth of the valley, while in their lower courses we find flood plains and meanders, showing the maturity of the stream.

Along the valley sides we usually find springs at the contact line of overlying pervious strata with underlying impervious strata.

All the above characteristics mark the present driftless region of the state.

Now let us see what the general surface of the present drift covered region in the late Pliocene times.

In tracing the various physiographic provinces of Indiana, we saw how the underlying rock in central, northern and eastern Indiana is the same as in southern and southwestern Indiana. The Devonian valley of the driftless region being continuous with northern Devonian valley of the drift covered region. The Cincinnati Island being so thinly covered that its rock basement outcrops continually. And the western upland only being covered at its northern end. We have other evidence of the continuity of the rock basement in well logs which are especially

full in the case of gas and oil wells. Also the drift has in it bowlders dragged from the underlying rock which shows the constitution of the underlying rock. Likewise, we have, in numerous places throughout northern Indiana, shown by well borings the presence of deep river valleys under the drift. So all this evidence of the continuity of the rock surface in both the drift covered and the driftless region, the presence of buried drainage channels, etc., convince us that before the glaciers came, drift covered Indiana must have looked considerably driftless.

That is, there was thin soil on the valley slopes. This is shown in the region of the Illinoian drift. There the drift is thin on the slopes where the thin soil allowed the ice to move fast and thick in the valley bottoms where the residual soil impeded the ice and added to the moraine deposits.

In the valley bottoms were alluvium flood plains. In the valleys having the same kind of rock we would find the same general kind of valleys. The tracing of buried channels as the one from Shelby County, Ohio, to Blackford County, Indiana, has shown this. The main streams followed the strike of the outcrops and their tributaries the dip. In the upper courses the streams were young and in the lower courses older. While the presence of the water table far up in the drift might show a contrary fact, still in getting good wells in the drift region as in Indianapolis, the driller goes below the drift, below the black shales, almost to the bottom of the pervious limestone, showing practically the same occurence of water conditions in the drift region as in the driftless, a pervious strata underlain by an impervious one.

Conclusion.

To conclude this review of Pre-glacial Indiana, I will quote the words of an observer of a section of the drift region as to what he thought Indiana looked like just before the coming of the ice fields.

Capps, U. S., Water Supply Paper No. 254, p. 24.

"The land surface was cut into ridges and valleys and the streams established well developed drainage lines. This was the condition at the beginning of the glacial period."

CHAPTER II.

THE COMING OF THE GLACIAL LOBES.

During the late Pliocene times of the Indiana which we have just reconstructed, a gradual change was taking place in the climate.

Chamberlin and Salisbury, Vol. III, p. 320.

It was becoming cooler as evidenced by the plant and animal life. It was less humid. With this cooling, slowly there advanced from the north and northeast great ice lobes which covered Indiana at times almost completely, and at other times retreated to the north and northeast to return again and again.

THE CAUSE OF PLEISTOCENE GLACIATION.

Now to account for this cooling of the atmosphere and the advance of the ice lobes from the north, many of the world's best physicists, physical chemists, astronomers and geologists have applied themselves with the result that we have a number of hypothesis which we will review.

THE ELEVATION HYPOTHESIS.

Chamberlin and Salisbury, III. pp. 424-6.

As today we find most of the glaciers on elevated tracts of the earth, so many geologists think that to produce the enormous bodies of continental glaciers which must have existed in the Pleistocene times, we must have had great elevations in that time on whose tops were produced the continental glaciers. Now this sounded very reasonable until we began to learn more concerning glaciation in earlier periods of the world's history. We learned that there was extensive continental glaciation of Australia, South Africa, and India, not more than 23 degrees north or south of the equator in Permian times. Also we found out that Australia and South Africa were not elevated tracts at that time. So the elevation theory of the origin of Pleistocene glaciers is not borne out by the Permian glaciation facts. Likewise, why should not the greatest elevated tract of the world, India, be glaciated today as it was in Permian times before it was elevated? Another objection to this hypothesis comes from its inability to account for

the successive advances and retreats of the various ice fields within a comparatively short time. Altogether the objections to this hypothesis have caused it to be dropped as a theory to entirely account for Pleistocene glaciation.

The Crollian Hypothesis.

Chamberlin and Salisbury, III. pp. 426-31.

At the present time due to the inclination of the earth's axis and the ellipticity of its orbit, at the time that the northern hemisphere is closer to the sun, we receive the less direct sunlight and vice versa when we are the farther away. But in 10,500 years the conditions will be reversed. Then when the northern hemisphere is the closer to the sun it will receive the greater amount of direct rays of the sun during a short summer and during a long winter it will receive the less amount of rays. According to the Crollian hypothesis this will produce conditions which will bring about glaciation in the northern hemisphere in 10,500 years and glaciation in the southern hemisphere 21,000 years hence. This theory would be workable were the facts of Pleistocene glaciation in accordance with it. But they are not. For instance, we know that the Labradorean ice fields advanced at least 1,500 miles from its gathering ground. Now if we allow 365 days in each year for it to advance, giving it one foot advance each day, it would take it 21,698 years to advance 1,500 miles, as long as the hypothesis allows for both the advance and retreat. This objection seems to invalidate the hypothesis to wholly account for the Pleistocene glaciation.

The Wandering of the Poles.

Chamberlin and Salisbury, III. pp. 431-2.

If the poles should be pulled further south and north of their present positions, according to another theory, we would have polar ice caps created in the new polar regions, which would be continental glacier centers from which would move out ice fields. The fields would then repeat the glaciation phenomena of the Pleistocene and Permian times, with its localization of ice fields. This theory has many advocates, especially among those who believe in a liquid interior of the earth. The rolling of this molten mass in the interior of the earth causes the shifting of the poles according to them. But as most of the geologists of today believe that the earth's interior is a rigid mass, there are few who can postulate a

force great enough to cause the shifting of the poles 15 to 20 degrees which would be necessary to bring about the localization of the ice fields of the Pleistocene times, in North America and Europe. To back up this objection an intensive observation of the wandering of the north pole during the last twenty-five years discloses the fact that it has wandered in a very small circle during that time. So this theory, also, to wholly account for Pleistocene glaciation, is being dropped.

The Depletion Theory.

Chamberlin and Salisbury, III., pp. 432-445.

A more pretentious theory has been set out by Arrhenius and other European physical-chemists and broadened by personal studies and elucidated in this country by Chamberlin. The basic facts in this theory are that during Pliocene times we had a continuation of the Tertiary uplift movements, with the consequent increase of land surface. The result of these movements was the increased consumption of carbon dioxide by land vegetation. This, with the shifting of currents poleward, lead to the greater depletion of the atmosphere of its carbon dioxide both by the vegetation and the cooling waters. With the decrease of the CO_2 in the atmosphere more and more sunlight was radiated back into space with the consequent fall in the earth's temperature. With the fall of the earth's temperature snow fields commence to form with consequent glaciers which moved out from the centers. As the continental glaciers covered more and more of the earth's surface and the cooled waters of the ocean became super-carbonated, a reverse movement toward the repletion of the CO_2 in the atmosphere commenced with a consequent rise in temperature and the retreat of the glaciers. This pendulum-like swing repeated itself until we think it reached its lowest node and has finally died out; in this recent period at least. This theory seems to conform to most of the observed facts and is widely accepted throughout the geological world.

Annals Astro-physical Observatory, Vol. 2, 1908, p. 172, 175.

However, since Chamberlin stated his views on this theory, it has been discovered by later observers that it is water vapor rather than carbon dioxide which plays the part of blanketing the sun's rays. So if in the above we substitute water vapor in the place of carbon dioxide we may thus account for fluctuating temperatures and consequent glacial periods.

The Localization of the Ice Fields.

Chamberlin and Salisbury, III., pp. 330-333.

Whatever the cause of glaciation, we do know that at the beginning of Pleistocene times in North America that ice fields began to move out from certain definite forming centers.

The Cordilleran Field.

The one which still has remnants left is the Cordilleran field. This lay in the Canadian Cordilleran plateau of British Columbia, surrounded by mountains. This center was more of the Alpine type of merged glaciers than of the continental type of further east. The striations made by the ice field in moving over the bedrock show that it moved principally to the west through the passes of the coast range; also, it moved south but whether much beyond the United States border is undetermined.

Note—However, Stewart, (Journal of Geology, XXI, 1913, p. 430,) believes it moved further south than credited at present. There was also some movement east and some to the north-west. This icefield however played little part in the glaciation of the United States and absolutely none in that of Indiana.

The Keewatin Field.

West of Hudson Bay on an old Precambrian plain gathered another ice field which moved out from its center principally south and southwest 1,500 miles to Kansas and Missouri and west and northwest 800 to 1,000 miles to the foothills of the Rockies. This was a continental glacier with a probable level center and steep sloping fronts on its edges. As to its thickness, no intensive or accurate studies have been made, but the thickness of morainic deposits show that it must have been considerable. The deposits of this ice field lie thick in our western states.

The Labradorean Field.

East of Hudson Bay gathered another ice field which was of great importance to Pleistocene Indiana. Its greatest movement was to the southwest where it reached 37 degrees 30′, about 1,600 miles from its source. This field was responsible for the glaciation of New England, the East-central states, Ohio, and a great part of Indiana, as well as further west. Its traces are shown in the Archean bowlders of its parent area which are strewn throughout the drift of this region.

The Successive Ice Advances and Retreats.

Criteria.

The successive advances and retreats of the Keewatin and Labradorean ice fields have been worked out at their ice edges, where they made their last morainic deposits. By a careful field study of the drift, the till, the bowlders, the pebbles and the topography of the morainic hills over the drift covers region along with a study of the peat beds laid down between successive drifts, glacialists have been able to determine a series of criteria by which they identify the age of the various deposits they meet. To check these they also use the direction of the striae which are found on the bedrock over which the ice field passed. These criteria seem rather indefinite to a stragraphic and lithologic geologist but evidently field work with them makes them more certain tools to work with, in the hands of the glacialist.

The Succession in North America.

Chamberlin and Salisbury, III., pp. 383-405.

Chamberlin has worked out a succession which has been the standard section for a number of years. His succession with Leverett's identification of the Indiana section is as follows:

Chamberlin's North American section; bottom up.			Leverett's Indiana section (Dryer's). U.S.G.S. Mon. No. 38, 41.,
I.	Subaftonian	Earliest glaciation	Wanting
II.	Aftonian	1st interglacial	Wanting.
III.	Kansan	2nd glaciation	Wanting.
IV.	Yarmouth	2nd interglacial	Not identified.
V.	Illinoian	3rd glaciation	Illinoian of Southern Indiana.
VI.	Sangamon	3rd interglacial	Probably in patches.
VII.	Iowan	4th glaciation	Loess present in Southern Indiana. Dr. Beede finds edge of driftless region.
VIII.	Peorian	4th interglacial	Not identified.
IX.	Early Wisconsin	5th glacial	Early Wisonesin.
X.	Unnamed interglacial	5th interglacial	Peat beds of Western Indiana.
XI.	Late Wisconsin	6th glacial	Late Wisconsin.
XII.	Lacustrine	Retreating	Lake Maumee etc.
XIII.	Champlain stage	Last submergence	Early present Wabash.

The European Succession.

Glacialists have been especially busy in Europe for a long time, working out the succession of the Pleistocene ice fields. A few years ago, one of our most noted field workers in glaciology, Mr. Frank Leverett, spent a year in the European field and in 1910 gave us this correlation of European and North American sections.

Leverett, Zeitscrift Gletscherkunde, 1910, pp. 241-336.

England.	Germany	Alps.	Alps foreland.	North America
.....	Scånian.....	Gunz.....	Older Decken-scotter.	Subaftonian
Norfolkian....	Paludinenbank....	Gunz-Mindel.....		Aftonian.
Old Drift....	Lower Diluvium	Mindel.....	Younger Deckenscotter	Kansan.
.....	Rixdorf.....	Mindel-Riss		Yarmouth.
.....	Middle drift.....	Riss.....		Illinoian.
.....	.....	Riss-Würm.....		Sangamon.
Younger drift .	Upper Diluvium.	Würm.....	Unterrassen.....	Wisconsin.

This is the first attempt of any importance at correlation by a field worker in both countries and will probably be improved upon by later students in both fields.

The Indiana Lobes.

As will be noted from the above, there is present in Indiana, deposits from the Illinoian to the late Wisconsin times and it might be well to point out some facts concerning the lobes of the ice fields which made these deposits.

The Illinoian Lobe.

Leverett, No. 38, pp. 22-31.

This lobe pushed down from the Labradorean region and occupied all of Indiana with the exception of a triangle of counties east of the Wabash and White Rivers, south of Morgan County and west of Columbus, Seymour, Brownstown and New Albany.

The Saginaw Lobe.

Dryer, 17th Ind. Geol. Report, pp. 131-32; 18th Ind. Geol. Report, pp. 28, 227.

Advancing down Saginaw Bay, a narrow tongue of ice was thrust out in front of the ice field and although not very heavy, as evidenced by its smaller moraines, it advanced from the northeast into Indiana as far as Fulton County. However, it was soon pressed back on both the northwest and the southeast by two larger and heavier glaciers, the Erie and Michigan Lobes and depositing its load of drift, retreated to the northeast forever.

The Erie Lobe.

This large and heavy lobe bringing with it bowlders and pebbles from the Canadian highlands came into Indiana from Lake Erie, occupied the great northern Devonian valley, and after awhile retreated slowly to the north, leaving great crescentic moraines behind along the Wabash drainage and interlobate moraines piled on the smaller Saginaw moraines through Kosciusko, Whitley, Noble, Lagrange, and Steuben Counties.

The Michigan Lobe.

This lobe coming from the Canadian highlands was forced to the west by either the Erie lobe or the easy slope of the Michigan valley. It covered northwestern Indiana down past the Kankakee at least. When it retreated, it left behind the rolling Valparaiso moraine and long remained in the Michigan lake bottom supplying the water from its ice front which made glacial Lake Chicago.

The Length of Time.

As we almost touch the Pleistocene time, it is of great importance to us to estimate its length and the time which has elapsed since.

The Time Elements.

To judge correctly the length of Pleistocene times, there are many elements to consider First, there is the time of the gathering ice fields, a mazy period. Second, there is the time of advance of the ice field, an estimate based on moving ice fields today. Third, the time of retreat, an estimate based on present glaciers, present ice fields, and the field study of weathered drift, and weathered peat beds. Fourth, there is the time of rest and interglacial

periods. Lastly, there is the time since the last retreat up to now, a fairly accurate estimate of which is being made by the study of Niagara Fall's rate of cutting its gorge. Now all of these vary in the case of the successive sheets, and so only general estimates have been made.

Some Time Computations.

Chamberlin and Salisbury, III., pp. 413-421.

Chamberlin has given the following estimate of the length of Pleistocene times.

1 time unit—Climax of Late Wisconsin to present day.

1 unit	Climax of Late Wisconsin	20,000—	60,000 years ago.
2-2½ units	Climax of early Wisconsin	40,000—	150,000 years ago.
3-5 units	Climax of Iowan	60,000—	300,000 years ago.
7-9 units	Climax of Illinoian	140,000—	540,000 years ago.
15-17 units	Climax of Kansan	300,000—	1,020,000 years ago.
X units	Climax of Subaftonian	x	y....years ago.

Penck and Brückner after an intensive study of Alpine glaciation extending over many years, give us the following estimate of European Pleistocene time extension:

Penck and Bruckner, Die Alpen im Eiszeitalter, Vol. III.

1 time unit...Würm to present time.

1 unit	Würm (Wisconsin)	16,000—	24,000 years ago.
3 units	Riss (Illinoian)		60,000 years ago.
12 units	Mindel (Kansan)		240,000 years ago.
18 units	Gunz (Subaftonian)		360,000 years ago.

It will be noted that the North American Pleistocene is some longer than the European Pleistocene, provided they were contemporaneous. However, these figures are not to be taken literally, but instead they represent more or less varying periods of relative time.

The Time Since.

Glacialists have been more successful in their estimate of the time elapsing since the lacustrine stage of the Pleistocene. G. K. Gilbert and Frank Taylor have taken the rate at which Niagara

cuts its gorge back each year and after getting a mean, they have laid this foot rule down and measured the valley of the Niagara from the falls to the escarpment at Kingston. The latest results of Mr. Taylor's study gives an estimate of 20,000 to 30,000 years, since the last ice left the Erie basin. This estimate coincides fairly well with Penck and Brückner's estimate of time since the last stage of Alpine glaciation, the Würm.

Conclusion.

We have seen something concerning the cause of the glacial period, something concerning the immense ice fields, and the way in which they followed one another. We have also estimated the length of time of this work. Now let us study what these glacial lobes left behind them.

CHAPTER III.

THE GLACIAL DEPOSITS.

When the ice lobes, which we have just described, were advancing into resting on, and retreating from the surface of Indiana, they were doing physiographic work which was to change the face of Indiana radically. This work was that of cleaning off the rotten rock from the decayed rock surface and filling the valleys and hilltops with masses of clay, sand, gravel, pebbles and bowlders. This drift was pushed on under and in the mass of the ice lobe and was left on the land when the ice lobe melted and retreated. Some of it was washed out from under the edges of the lobes and in stratified beds it lies down the river valleys or as great outwash plains on the uplands. But, in the great part of the drift was left inextricably mixed, clay, bowlders, sand, gravel, and pebbles, either as morainic hills when the ice paused in its retreat for awhile or as a gently undulating ground moraine plain, which the ice left behind in its steady retreat northeast and north.

The Moraines.

As the most prominent feature of glacial deposits are the moraines, let us look at some Indiana moraines for a time.

Method of Deposit.

Early glacialists in studying continental glaciation discovered the remarkable resemblance between certain continental deposits and the terminal moraines of mountain glaciers. So by a careful study of mountain glaciers they have come to the conclusion that the large morainic ridges running in many directions over central and northern Indiana were formed from the rotten rock pushed forward by the ice lobes. When the ice stood still for a time, at its edge accumulated a greater load which rested as a ridge along the ice front. Often in front of this ridge, the glacier draining streams made outwash aprons and kames of stratified gravel and sand. Then when the ice commences to retreat again, these ice front deposits were left as ridges, knolls, etc., on whose surface the weathering agents commenced to work, making them still more diversified. This is the moraine of today.

The Appearance of the Moraines.

Leverett, No. 38, p. 195; Ibid., No. 41, pp. 512, 539, 570.

The general characteristics of moraines which one notices as he rides from Indianapolis to Richmond or from Indianapolis to Fort Wayne or Chicago, is that they are ridges. Often these are single ridges as in the case of several of the late Wisconsin moraines southwest of Indianapolis. At other places they are parallel ridges, as in the case of the Valparaiso moraine in places. Still, again they may be a broad rise covered with knolls standing 10 to 20 feet above the drift with hollows irregularly occurring between them. This kind of topography Dryer found in Whitley County, especially. In these hollows are where the beautiful Indiana lakes of kettle hole origin in Noble, Steuben, Lagrange and Kosciusko Counties occur. However, the ice may have stood at this moraine edge such a short time that these knolls, hollows and undulations are conspicuous by their absence. And it is only as in the case of the Illinoian moraines, by viewing the front relief of 30 feet to 50 feet that we see that we are on a morainic ridge. In fact it only after long field identification of glacial deposits that one can make a general classification of morainic ridges. On this point Dryer has shown the great extremes in the same kind of morainic ridges.

Dryer, 17th. Ind. Geol. Report, p. 163.

In Whitley County in describing the Mississinewa moraine he says: "The country is entirely occupied by deep irregular, elongated valleys with narrow, sharp winding ridges between, all in inextricable, indescribable and almost unmappable confusion. It covers in all scarcely more than 40 square miles, and the greatest differences of level do not exceed 100 feet. The roads through it are very crooked in order to avoid the marshes, ... The ridges are composed of rather barren clay and the valleys occupied by marshes and tamarack swamps, ... Another strange peculiarity is that a country which so abounds in depressions is almost devoid of lakes."

Then in contrast he says: "The first and second moraines, (the Fort Wayne and the Wabash), are well defined ridges,but present only occasional evidences of the peculiar topography regarded as characteristic of terminal moraines. Hills, knobs, kames, kettle holes are chiefly conspicuous by their absence."

Dryer, 18th Ind. Geol. Report, p. 88.

The Composition of the Moraines.

In order to appreciate the economic importance of these moraines, a glance at their physical and chemical makeup is instructive. The sections are usually obtained in railroad cuts, stream banks and knolls which have been opened to obtain gravel.

The importance according to the occurence of the constituents in the morainic ridges are glacial till (glacial clay), sand, gravel, pebbles, and bowlders, all unstratified.

Capps, U. S. Water Supply Paper, No. 254, pp. 29-30.

This glacial till or rock rot as Chamberlin and Salisbury called it in 1885, is the usual matrix in which we find bowlders, pebbles, etc., as Capps says: "They consist of a heterogeneous mixture of glacial debris, composed of great bowlders, pebbles, and blocks of rock, mixed indiscriminately with sands and clays. The common matrix of this unstratified mass is a blue clay." This till is the Miami clay loam of the Indiana soil reports and although a heavy, cloddy soil makes extremely rich corn land.

The Sand and the Gravel.

The beds of sand and gravel vary in color and texture according to the nearness of the deposit to water courses and lakes. In the Valparaiso moraine we find much dune sand while the gravel pits around Indianapolis show rough angular brown to gray grains of sand gravel. These pockets of sand and gravel are what make the knolls of the moraines so valuable. The roads of the surrounding are always graded from this material. And as we use more and more concrete in our building operations, more of these sand and gravel deposits will have concrete block factories located near them.

The Bowlders.

Leverett, No. 38, pp. 66, 356-7. Ibid., No. 41, pp. 37, 261, 574-5.

Strewn on the surface in belts and mixed in the till are many large bowlders running from the size of one's fist to the size of a bushel basket or larger. These bowlders are granites, gneisses, schists, quartzites, greenstones and sandstones of the Canadian highlands and limestones of the Ordivician, Silurian and Devonian times of Indiana. These bowlders are interesting geologically as

they tell us of the parentage of the deposits, but economically they are a hindrance to the cultivation of the farm lands. The early cultivators of northern Indiana not only had to clear the land of trees, but they had to clear the land of bowlders also. And today, even, they are ploughed up and must be stacked in the fence corner to accumulate weeds around them. The only economic use I ever noticed these have been put to, is to make cobble-stone porches, fire-places and fences.

Note—In a fence about a square long and 3 feet high in Irvington, I have found that the bowlders average 1 foot in diameter and are about 75 per cent of Algonquin and Archean origin. These bowlders were hauled in from the surrounding fields.

The Drumlins.

Undoubtedly these long ellitical hills composed of morainic material which accumulated under the lobes must be present in Indiana. But none of the observers whose reports I have read have described any and so I conclude that either the conditions for their formation were unfavorable or else they have not been identified yet.

Eskers.

These beds of sub-glacial streams which now show as smooth-sided ridges which wind across the ground moraine like snakes, have been found by Dryer in Noble County.

Dryer, Jour. Geol., IX., pp. 123 et seq.

There High Lake lies between two branches of one. Further west he found another esker, $2\frac{1}{2}$ miles long, and 40 feet high, which makes an almost complete loop around Gordy Lake.

Leverett, No. 41, pp. 475-84.

Leverett found what he thought was an esker leading north from Muncie, almost connecting the Union and Mississinewa moraines. These deposits are made up of stratified beds of gravel and are valuable as a source of road metal.

Some of the Indiana Moraines.

Leverett, No. 38, pl. VI. Ibid., No. 41, pls. II., XI.

These ridges with their varied topography and varied composition wander over Indiana varying the surface and changing the preglacial drainage to a remarkable degree. Let us locate some of them.

The Illinoian Moraine.

This moraine is difficult to trace as its edge is not marked by a definite ridge. We can only tell when we come to the border by the drift deposits dying out, the pre-glacial surface appearing with the pre-glacial drainage on it.

Leverett, U. S. W. S. P. pl. II.

The border of this moraine enters the state from Illinois at Mt. Vernon and runs northeast past Petersburg nearly to Shoals, then north along the western edge of Monroe County which it cuts on the north. After cutting east along Bean Blossom in Brown County, it drops south along the Bartholomew County line, west of Seymour and Brownstown. Then it strikes southeast to about Charlestown where it crosses the Ohio and parallels it on the south to the eastern border of the state.

Leverett, No. 41, pp. 271-2, 283-5.

This border region is characterized by a stony clay usually yellow for 5 or 6 feet down and then blue clay throughout the drift below. There are present some sand and gravel beds but no bowlder belts.

The Shelbyville Moraine.

Leverett, No. 38, pp. 191, 193, 194, 195, 197, 198, 208.

This moraine of the early Wisconsin glaciation, (according to Leverett), is marked by a sharp rise of 20 to 50 feet in the relief at its border on the underlying Illinoian drift. However, there are a few ridges and knolls only on its surface. So it is difficult to trace as it comes into the state west of Terre Haute, then north along the Wabash River, where in northern Vigo County it crosses the Wabash River to Parke County and continues north on the divide between the Wabash and Big Racoon Creek to Montezuma. It then goes east across Parke County to Bainbridge, where it swings south to near Greencastle. From here it moves east and south through Putnam and Morgan Counties past Mooresville and from here on to the south of Franklin in Johnson County it becomes feebler and in the latter county is finally over-ridden by a later Miami lobe glacier. This moraine is made up of brownish yellow till for 6 to 8 feet down. Below this exidation line it comes a blue gray till. In the average, 40 feet of morainic deposits there are some sand and gravel beds.

The Union Moraine.

Leverett, N. 41, pp. 475-9; 480-4.

Entering the state at Union, Indiana, and continuing west down the north side of West White River through Randolph County to Selma in Delaware County is a smooth gentle ridge with undulating surface. The swells on it rise 15 to 30 feet above the surrounding plain. A typical section of the morainic ridge would show:

4. Yellow till.
3. Gravel.
2. Sand.
1. Blue till.

The Mississinewa Moraine.

Leverett, No. 41, pp. 494-6, 498, 500, 505.

The Mississinewa moraine with its front covered by knolls and hollows, filled at places with lakes, rising 20 to 75 feet above the surrounding plain is a noticeable landmark as it comes into the state north of Ridgeville, continues west past Dunkirk and Hartford City; then parallels the Mississinewa for quite a distance and finally crosses the Wabash River above the city of Wabash. From here it strikes to the northeast past Columbia City and Albion and goes out of the state in Steuben County, merged with the Saginaw interlobate moraine. This moraine, of grayish yellow till for 10 feet down and grayish blue below, is 50 to 500 feet thick. Lying on its surface are many bowlder belts.

The Wabash Moraine.

Leverett, No. 41, pp. 545-8, 552-5.

This moraine, which is almost sagitate in outline has much the same topography as the Mississinewa, and was probably formed under about the same conditions of retreat of the Erie lobe. It has an abrupt bluff-like front. Its ridge is varied by knolls. The slope behind runs back a mile or more. It is about 20 feet in thickness. It is mostly glacial till with little gravel, showing poor drainage from the ice front at that time. Much of the ridge is covered by oaks. The moraine reaches from Geneva, northwest past Bluffton and crosses the Wabash River just west of Fort Wayne. Here it turns northeast past Auburn and Butler.

The Valparaiso Moraine.

Leverett, No. 38, pp. 339, 345-7, 353, 356-7.

This massive moraine, encircling Lake Michigan in Lake, Porter and Laporte Counties, marks the site of the Michigan lobe when it was being drained south through Lake Kankakee and the Illinois River. It can hardly be separated into ridges and is mostly glacial till although there is more sand and gravel north of Valparaiso than there is to the south of that place. The moraine is marked by knolls, which make it a landmark.

Contrast of Moraines.

Dryer, 17th. Ind. Geol. Report, pp. 117-8.

Dryer has contrasted the Erie and Saginaw lobes' moraines in the following observation, "This valley, (west of the Mississinewa moraine) is an important feature in the topography, because it marks distinctly the dividing line between the Erie and the Saginaw drift.....On the east the hills and the dunes of the fourth Erie moraine are piled in indescribable confusion. The country on the west has about the same general elevation, and is distinctly morainic in character, but is very much more smoothed out. The slopes whether gentle or steep, are broad and plateau-like, their evenness being broken only by an occasional small kettle hole.

The Drift.

We now come to the most important, economically, of the glacial deposits, the drift. Under that heading we will include, not only the ground moraine, but also the outwash plains, the inner border deposits, and the old glacial lake bottoms.

The Method of Deposition.

As the ice lobes retreated, they deposited under the ice the glacial till which they made by crushing up the bowlders, pebbles, gravel, and sand gathered from the land they had moved over. The greater part of this till was a fine rock-flour which oxidized slowly when exposed to the weathering agents. This is evidenced by the fact that the drift is oxidized only to the distance of 5 or 6 feet down although it has been exposed for more than 20,000 to 60,000 years.

The Appearance of the Drift.

Leverett, No. 41, pp. 271-2.

Back from the moraine ridges the ground moraine is a flat, almost featureless plain. From north of Morgantown to nearly Indianapolis, the I. C. R. R. passes through considerable of this kind of country. A trip on any of the northern interurbans out of Indianapolis shows any number of these ground moraine plains, almost as level as a billiard table. The only undulations in the plains are made by the young creeks just beginning to cut into the plain. On these plains the roads run straight on the section lines, and the farms are quarter, half, and whole section size. This is also the country where the farmers grow rich from the yield of the Miami and other clay loams.

The Composition of the Drift.

Leverett, No. 41, pp. 222, 225-6, 254, 261.

The Illinoian drift of southern Indiana is a stony till. It is also thin, especially on the hill tops. Throughout it we find Canadian bowlders mixed with native rocks. A few sections may show its composition more clearly.

Leverett, No. 41, pp. 263-70.

Section in Beanblossom Valley near Needmore, Ind., 50 feet of brown, stony, almost gravelly till.

Section near Chestnut Ridge south of Seymour, Ind., 30-40 feet of fine clay and sand, yellow at surface, but blue at the depth of 16-18 feet.

Section in Ohio River bluff, (Split Rock), near Aurora, Ind., 5 feet silt, top of bluff; 50 feet gray to brown, fine to coarse sand, 50 feet rock outcrops 100 feet glacial conglomerate.

At the top where this drift is oxidized it is a brownish till, but farther down it is a bluish till. It is harder than the later Wisconsin till, due to the cementation of the lime flour in the till. The soil which comes from the breaking down of this till, is a harsh soil to work. It dries out easily and does not yield grains abundantly as does the Wisconsin drift covered region. In fact the whole range of Illinoian drift covered counties does not compare in agricultural wealth with the Wisconsin drift covered counties, according to the 13th census, (Vol. 6, Agriculture, pp. 460-1.)

The Wisconsin drift plain is also flat and undulating. Throughout it we find Canadian bowlders mixed with a few native rocks.

Leverett, No. 21, U. S. W. Paper, p. 10.

The sections show an average thickness of 130 feet with yellowish till the first 10 feet or so, followed by grayish blue till beds of unstratified gravel and sand. The soil of this Wisconsin drift covered region is heavy to work and requires a great deal of cultivation to keep it in shape. However, it yields abundantly, especially in the case of corn. The alternations of clay and sand usually give a soil which absorbs moisture fairly and yet not too fast to allow the roots of the growing crops to take it up as needed. The Wisconsin drift covered counties are the great farming counties of the state and give Indiana the rank she has among the agricultural states.

The Bowlders and Pebbles.

Leverett, No. 41, pp. 263-70.

The bowlders and pebbles of the drift are of the same general kind as are found on the surface of the moraines in the Bowlder Belts. Leverett gives this analysis of a gravel knoll of Illinoian age near Lancaster, Ohio.

Granite—2 per cent of total number of specimens.
Precambrian—9 per cent of total number of specimens.
Chert—2 per cent of total number of specimens.
Quartz—3 per cent of total number of specimens.
Ironstone—2 per cent of total number of specimens.
Sandstone—36 per cent of total number of specimens, (local.)
Limestone—46 per cent of total number of specimens, (local.)
Total 100 per cent.

In Union County, Indiana, he found in a Wisconsin drift region, that only 5 per cent of the pebbles were Canadian in origin. Also in the Salamonie ground moraine he found many fossils of the local Ordivician, Silurian and Devonian limestones. The above shows fairly clearly that while the larger bowlders are mostly Canadian, the smaller ones and pebbles are mostly native rock. This can be accounted for on the ground that the Canadian rocks being of higher specific gravity gradually road higher in the ice lobe and were subjected to less wear and so were deposited last in the morainic ridges or in the top layers of the drift.

The Old Glacial Lake Bottoms.

Leverett, No. 38, pp. 334-8, 424-59.

As the ice lobes retreated, the water from the melting ice front often ponded there and formed glacial lakes. The topography of these old glacial lake bottoms is always easily recognized. The level flat stretches, with not a break in them, is usually bounded by a ridge marking an old beach line. The old glacial lake bottoms are numerous in Indiana, reaching from old Lake Patoka and Lake Flatwoods in southern Indiana to Lake Maumee and its successors and Lake Kankakee in the northern part of the state. When the mucky soil, made up of decayed vegetation, is thoroughly drained, either artificially or naturally, the old lake bottoms become rich farm lands.

The Outwash Plains.

Leverett, No. 38, pp. 208, 375. Ibid., No. 41, pp. 329, 379, 578-9.

Beyond the moraines, stretching down the Whitewater, the Wabash and the Kankakee Rivers are level plains of sandy and gravelly loams. Again on the divides between these streams lay plains of the same kind. At other places, as in the case of the Shelbyville moraine, this plain is almost entirely silt. These outwash plains were formed by the drainage away from the ice front. As the current varied from strong to sluggish, so the deposits vary from coarse gravel to fine silt. These bottom lands are also desirable from an agricultural standpoint.

The Inner Border Plains.

Leverett, No. 38, p. 213. Ibid., No. 41, pp. 561-2.

Close behind the morainic ridges and the ice front, as in the case of the Erie lobe, there was poor drainage and here were swamps and here today we find much black soil, suitable for truck farming.

Conclusion.

In this chapter we have briefly reviewed the moraines and the underlying drift. We have seen something concerning their composition and appearance. We have located some of the chief ones also. Now let us see something concerning the changes in topography brought about by these deposits and the ice lobes which formed them.

CHAPTER IV.

THE TOPOGRAPHIC WORK OF THE ICE LOBES AND THEIR DEPOSITS.

Introduction.

In speaking of the topographic work of the ice lobes and their deposits on the surface of Indiana, let us see what one observer has to say concerning this phase of the Pleistocene history of Indiana.

Capps, U. S. W. Paper, No. 254, (1910), p. 26.

He says, "The ice, moving slowly south, first removed all the soil and loose materials, and then with its base shod with fragments of rock frozen into the ice, gradually wore down the hills and smoothed off the most prominent irregularities. Great quantities of rock debris were picked up and carried by this ice sheet.....The materials which the ice gathered in its southward journey were deposited toward the south or melting edge of the glacier. Much was deposited beneath the thinning edge of the glacier as till, filling depressions and grading over worn rock surfaces."

The Soil.

When the ice withdrew, it left behind drift till, moraines and lakes and with the help of glacial and post-glacial streams these have been spread over glaciated Indiana giving us many different kinds of soil provinces. They are:

(1) Till plains, from the ground moraine deposits especially. These are the rich farms, adapted to grain raising and general farming.

(2) Outwash plains and aprons, stream deposits from the terminal moraines. They have on them orchards suited to the sandy subsoil.

(3) Old lake bottoms, from vegetation accumulating in ice front lakes and inter-morainic ridge lakes. When the soil is properly drained and sweetened they make magnificent truck farms, suitable for raising onions, celery, etc.

(4) Morainic ridges, ice edge deposits on which can be planted orchards and from whose subsoil can be procured any amount of clean gravel for building and road purposes.

Leverett has made a classification of glacial soils according to their composition, which is useful along with my table above.

Leverett, No. 41, pp. 778-81.

His table, as paraphrased by the writer, follows:

Name.	Origin.	Distribution.	Remarks.
Residuary.	Bedrock.	Driftless Indiana.	.....
Stony clay.	Glacial till.	On most of the moraines, most of till plains of Wisconsin age. On valley slope of Illinoian age. On	Very productive; porous; the good farm land of greater part of Indiana.
Gravelly or stony.	Glacial outwash; old lake beaches.	interlobat moraines of Wisconsin age; on some Wisconsin moraines; on some Illinoian drift; on glacial outwash; on stream deposits; on deltas in glacial lakes; old glacial lake beaches.	
Sandy.	Glacial drainage; glacial streams; glacial lake beaches.	On beaches of glacial lakes; on lake bottoms; in valleys.	Least productive.
Silty or Clayey.	In part from slowly moving waters; some by winds; also from glacial lakes.	In Maumee region; in Illinoian region.	
Peaty.	Vegetal accumulation and shells.	In regions of imperfect drainage; old lake bottoms.....	Yield large returns in truck farming.

Note—It is interesting to get Leverett's point of view on the formation of various kin ds of glacial deposit soils.

Leverett, No. 41, p. 776.

He says, "The soils of the glaciated portion of the Ohio River basin are largely derived from the glacial drift and the loess and lacustrine silts that cover the drift. . . . . The great agencies involved in producing the soils of the glaciated district, the ice

sheet, the glacial lakes, the glacial streams, have long ceased to operate, but modern streams are still at work spreading alluvium over valley bottoms in their flood stages. The small lakes that remain in the depressions of the drift are precipating marl deposits and when drained will give a rich soil."

These two above tables, when used together, one to identify the general region, the other to identify the special region, will give pretty clear field identification criteria for glacial soil.

The Hills.

Jour. Geol. XXI. (1913), pp. 422 et seq., 748 et seq.

As the ice lobes stood without advancing or retreating for long periods, as do the mountain glaciers of today, in front of them was carried out the gravel by sub-glacial streams and left there. These stratified deposits of gravel and sand Dryer has found in Northern Indiana and the author has also observed just south of Indianapolis on the I. C. R. R. These are kames and are a source of much good road metal. The I. C. R. R. has used the above deposit for much of its ballast from Indianapolis south for some distance.

While the ice lobe was retreating, some obstruction in its bed caused the accumulation of long, narrow, ellipitical, hills which now arise above the drift plains and furnish ideal locations for healthful homes. As noted above, none of these deposits have been identified in Indiana as yet.

If it were not for the morainic ridges crossing the sky line above the undulating till plains, glaciated Indiana would be rather dreary from an aesthetic point of view. But these ridges dimpled at places by knolls, 20 to 30 feet high, with clear lakelets or green dales between them, furnish variety to the scenery of northern Indiana and give Dryer some backing in his calling some of this region the "Switzerland of Indiana."

The Lakes.

Leverett, U. S. W. Paper. No. 182, p. 6. Ibid., No. 38, pp. 334-8, 427-59.

In front of the slowly retreating ice lobes, accumulated the melting ice which could not be drained away by the outlet as fast as it changed from glacial ice to ice-cold water. In front of the Erie lobe, in the Maumee basin, was such a glacial lake and as

the lobe retreated, exposing lower outlets, its basin outline changed and it built up a succession of lower beach lines. To this glacial lake has been given various names, according to the position of its beaches, such as Lake Maumee, Lake Whittlesey, Lake Warren, Lake Algonquin, Lake Nipissing, etc. In front of the Michigan lobe was a series of lakes, shallow and marsh-like, called Lake Kankakee. Later when the Michigan lobe retreated to Lake Michigan basin and the outlet wss shifted west, the ice front lake was called Lake Chicago. Scattered through Indiana were a number of lakes which were formed by the ice lobes backing up streams and ponding them. Such lakes were Lake Patoka, made by the ponding of the upper, middle and lower Patoka by the Illinoian lobe; Lake Beanblossom, formed by the ponding of Beanblossom Creek at Gosport and Lake Flatwoods in Monroe County. The effects of the presence of these lakes, all of which are known by the level stretches of rich farm land and the bluff-like beaches, was to change the drainage of pre-glacial times to that of the present day. These lakes also left behind rich farm lands, whose price is above that of the surrounding country. Also, a fact which is not of so great importance today as it will be a hundred years hence, they left behind them immense deposits of peat, almost lignitic today, an immensely valuable fuel asset to northeastern Indiana.

The Present Day Lakes.

Dryer, 17th. Ind. Geol. Report, pp. 123-7. Ibid., 18th. Ind. Geol. Report, pp. 73, 121-3.

As the present drainage began to establish itself, much of the water along the morainic ridges, especially in Steuben, Lagrange, Noble, Whitley, Fulton, Kosciusko and Elkhart Counties found itself compelled to wander back and forth through the dales scattered haphazard along the ridges. Finally most of them found an outlet to Lake Michigan or Lake Erie. The diversity of the valleys of these kettle hole lakes is what makes them so beautiful. For instance, Lake George (Steuben County) has low bowldery shores, while James Lake (Steuben County), is divided into five basins and one half mile further on is Jimerson Lake, shaped like a St. Andrews Cross. All of these lakes, which furnish ten miles of boating, are connected by Crooked Creek as an outlet. At places the lakes have high bluff banks, as Lake Gage (Steuben County), or sandy beaches as Lake Tamarack (Steuben

County), or it may be a wash bowl in shape as Clear Lake (Lagrange County), or only the expansion of a river as Mud Lake on the Kankakee. All of these lakes will gradually drain away and be replaced by marshes, which in turn will be drained by man and become farms, but before that, they will have done their work. At present they furnish for the people of Indiana, the most pleasant and safe boating grounds that I can think of. The beaches, sandy in most cases, invite one to take a plunge while down in the clear water you can see 150 species of fish which beckon to your line. Beside, many of the cities of this region use these lakes for reservoirs where can be collected clean, potable supplies of drinking water. Their psychological effect should not be forgotten, as there seems to be something in the nearness to these lakes which gives a certain "go" to the inhabitants, while making them genuine followers of Izaak Walton.

Dryer, 17th. Ind. Geol. Report, p. 134.

The present lakes have economic values which must not be forgotten, also. Dryer gives a classification of the Indiana lakes, based on the bottom of the lakes, which is valuable in pointing out their economic importance. He calls them, first, peat lakes, which will become covered up and bogged the soonest. Second, he has the lime lake, on whose bottom is accumulating the marl deposits which are so valuable in making cement. These will next be filled and disappear. And last, there are the sand lakes with bottoms of sand which will drain away the last and leave their sand to form the porous subsoil of a rich bottom farm.

Altogether I believe the lakes of the glacial deposits make the greatest appeal to me of any of the topographic work of theice lobes and their deposits.

River Valleys.

Leverett, No. 38, pp. 538-9.
Ibid., No. 41, pl. II.
Dryer, 17th. Ind. Geol. Report, pp. 167-8.
Ibid., 18th. Ind. Geol. Report, p. 88.

The morainic deposits lie in more or less parallel lines, marking successive stages in the retreat of the ice lobes. The result is that over northern Indiana was established new river valleys, through which flow post-glacial streams. For instance, the Mississinewa, the Salamonie, the St. Mary's and the St. Joseph, all flow northwest and southeast between the Mississinewa, the

Salamonie, the Wabash, the Fort Wayne and the Interlobate moraines. Their pre-glacial drainage was not at all like this we have tried to show in the first chapter. Beside this profound topographic work of creating new post-glacial river valleys, the ice lobes created post-glacial valleys in another way. The till plains, with their undulating or almost flat surface, invited the post-glacial streams to cut new valleys across them, as in the case of the upper West White River, the Elkhart and many others. However, this work was dwarfed in its importance by the number of drainage changes affected by the ice lobes and the drift.

Drainage Changes.

Leverett, No. 38, p. 460, 97-100, 230-1.
Ibid., U. S. G. S. Report, 1897, pt. 4., p. 439.
Dryer, 18th. Ind. Geol. Report, pp. 25-6.

Leverett has summed up the changes which ice lobes effect in the following way:

(1) New drainage systems.
(2) Major streams deflected.
(3) Minor streams deflected.
(4) Re-established or non-deflected drainage.

The first of these we have treated, and the others we will note in our discussion of this point. Beside creating new river valleys in Iudiana, the glacial deposits were laid across many drainage lines as a low flat till plain. This plain became the prairie country of northern Indiana today.

Not only did the glacial deposits produce well drained prairie lands as we have said, but often they left behind them, low, flat, sometimes hummocky, swamp lands in the place of the previously well drained country as in the interlobate counties of northeastern Indiana and the Kankakee valley.

In the matter of major stream deflections, we have already seen the post-glacial Wabash cutting to the east of its old valley near Covington. Also, at Louisville, the post-glacial Ohio pursues a different course from that of the pre-glacial Ohio. The upper Whitewater was probably reversed and the St. Joseph sent west to Lake Michigan instead of southwest to the Gulf by an ice dam and moraine below South Bend. To mention the reversed courses of the St. Mary's and the St. Joseph at Fort Wayne, shows another case or morainal deflection of major streams.

The cases of minor stream deflections are very numerous. We could speak of the new Patoka River, the deflected Coal Creek, in Fountain County, the changed McCormack's Creek, in Monroe County and many others. But that would give us material for another long and interesting study. So we will drop this question of topographic work of the ice lobes and their deposits after having shown something about the soil, the hills, the lakes, and the changed drainage left behind, to our present day.

General Conclusion.

In this short history of Indiana during the glacial period, we have seen how the pre-glacial Indiana must have appeared before the coming of the Pleistocene ice fields. Then we tried to account for the coming of the ice fields and particularly the ones which reached Indiana. The deposits which these ice lobes left behind, then studied in detail. And finally in order to see the importance to us of this glacial history, we saw the changes which were made on the surface of Indiana by these deposits, which made the Indiana that we know today.

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Soil Survey of Wells County.

By W. E. Tharp, U. S. Department of Agriculture and W. E. Wiley, Indiana Department of Geology.

Description of the Area.

Wells County is situated in the northeastern part of Indiana. It is bounded on the north by Allen, and on the east by Adams County, on the south by Jay and Blackford, and on the west by Grant and Huntington Counties. Its length from north to south is 24 miles, and its width is 14 miles, except in the extreme southern part, where it is 20 miles. The county embraces an area of 367 square miles, or 234,880 acres.

The greater part of the surface is a somewhat uneven plain having an elevation of about 850 feet above sea level. Throughout the northeastern, west central, and south central parts of the county the topography varies from nearly level to gently undulating. Except in the immediate vicinity of the larger streams that cross these areas, the differences in local elevation do not usually exceed 10 or 15 feet. The slopes are more pronounced along the lower courses of these streams, and become somewhat shorter and steeper as the rivers are approached, but in very few places are they so steep as to hinder the use of farm machinery.

In Jackson Township, which is the southwestern projection of the county, the surface features generally conform to the above description, except for a mile or more on each side of the Salamonie River. Here much of the upland is strongly rolling and there are numerous bluff-like slopes of 50 to 75 feet overlooking the narrow valley of the stream. The most marked development of such topography is found just below the mouth of Prairie Creek on the west side of the valley, where the margin of the upland is broken into steep ridges of unequal height.

A belt of relatively hilly land extends from the Wabash River at Bluffton, northward to Ossian, and thence in a northwesterly direction to the corner of the county. It averages about 3 miles in width, and although locally termed a ridge, is not very much higher than the country to the east, but is noticeably superior in

elevation to that on the west and south. The highest points rise about 100 feet above the Wabash valley. The surface in general, is undulating to strongly rolling, with the irregular "bumpy" contours characteristic of morainic topography.

A similar morainic ridge is found in the extreme southern part of the county, embracing most of the two southern tiers of the section from the southeast corner to the Salamonie valley, and extending thence along the north side of that stream into Jackson Township.

Excepting the narrow valleys of the streams, practically all the topographic features are morainic rather than erosional.

The Wabash River crosses the middle of the county in a northeasterly direction, and the Salamonie River has a similar course through the southwestern part. Their valleys are narrow and comparatively shallow, being nowhere more than 100 feet below the highest points of the adjacent upland. While the general course of the rivers and larger creeks is from southeast to northwest, much of the minor drainage is from southwest to northeast. This feature is observable in the trend of many of the low ridges and slight depressions. Practically none of the surface is untillable, except the steep acclivities that bound the stream valleys and a few very small areas of muck and peat.

The rivers and creeks are perennial streams and many of the larger ditches are fed by so many tile drains that they fail only during periods of exceptional deficiency in rainfall. Most farm wells are sunk through the till into the limestone, and an unfailing supply of excellent water is obtained. Few of them are more than 150 feet deep.

The first settlement in Wells County was made in Lancaster Township in 1829, but it was not until the late thirties that any considerable number of settlers had located within the county. In 1910, according to the census, the population of the county was 22,418, of which 77.8 per cent was classed as rural. The density of the rural population was about 48 persons per square mile. The population of Bluffton, the county seat, was 4,987, and that of Ossian, the next largest town, was 661. Other towns of local importance are Keystone, Poneto, Vera Cruz, Markle and Uniondale. The negro and foreign-born population of the county are small.

The Chicago & Erie and the Toledo, St. Louis & Western railroads cross the county from east to west, and the Lake Erie & Western Railroad from north to south. A local line between

Portland and Huntington also crosses the county from northwest to southeast. Two traction railways centering at Bluffton afford almost hourly service between that point and Ft. Wayne, Marion, and other towns in this section of the state. There is also an electric line from Bluffton to Celina, Ohio.

The public roads are well graded and surfaced with stone and gravel. Almost every farm house has telephone and rural delivery service.

The climate of Wells County, in common with that of all of northern Indiana, is comparatively uniform. The mean annual temperature, as recorded at the Weather Bureau Station at Bluffton, is 50 degrees F. The mean for the winter months is 25.8 degrees; for the spring months, 50 degrees; for the summer months, 71.1 degrees; and for the fall months, 53.2 degrees. The highest recorded temperature is 103 degrees in July and the lowest -23 degrees in January.

The mean annual precipitation is 36.94 inches, of which 10.88 inches falls during the spring months, and 11.70 inches during the summer months. This is sufficient to insure good yields of corn, alfalfa, clover and grasses where proper cultural methods are followed, but any marked deficiency in rainfall during the summer months affects the crops very materially. The average depth of snowfall is 23.5 inches.

The average date of the last killing frost in the spring is May 7, and of the first in the fall October 2, giving a normal growing season of 148 days. The latest recorded date of killing frost in the spring is May 31, and the earliest in fall is September 19.

The following table gives the normal monthly, seasonal and annual temperature and precipitation at Bluffton:

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT BLUFFTON

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year. (1910)	Total amount for the wettest year. (1913)	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	28.2	62	—12	2.56	2.23	1.27	5.0
January	26.8	70	—23	2.41	2.92	6.88	5.5
February	24.8	66	—19	2.28	2.15	1.60	6.2
Winter	26.6	70	—23	7.25	7.30	9.75	16.7
March	39.4	88	— 3	3.70	T	9.59	4.4
April	49.8	92	17	3.08	2.63	3.01	0.9
May	61.0	101	24	3.79	3.28	3.33	0
Spring	50.1	101	— 3	10.57	5.91	15.93	5.3
June	68.3	100	37	4.10	.96	1.71	0
July	73.9	104	42	3.54	2.07	8.83	0
August	72.1	101	36	3.20	1.35	4.87	0
Summer	71.4	104	36	10.84	4.38	15.41	0
September	65.7	100	28	2.66	4.53	1.79	0
October	53.4	94	17	2.10	2.37	3.34	T
November	39.9	80	9	3.02	3.01	2.05	1.5
Fall	53.0	100	9	7.78	9.91	7.18	1.5
Year	50.3	104	—23	36.44	27.50	48.27	23.5

Average date of first killing frost in fall, October 4; last in spring, May 7. Earliest date of killing frost in fall, September 14; latest in spring, May 31.

AGRICULTURE.

Practically all of the county was originally heavily forested and the removal of the timber and the drainage of the innumerable swampy tracts progressed rather slowly at first. In later years, however, through co-operative efforts in the construction of the larger ditches and the straightening of many small streams, the improvement of drainage was more rapid and effectual. With the exception of a very few small depression, all the former poorly drained lands are now tillable. The remnants of the original forest consist of groups of trees around farm buildings, small woodland pastures, and occasional blocks of 10 to 20 acres of comparatively heavy timber. Perhaps 10 per cent of the total area has escaped the plow.

Corn, wheat, and oats are the principal crops, ranking in the order named. In 1909, 57,242 acres were devoted to corn, producing 2,407,119 bushels.* In 1899, 51,833 acres gave approximately the same returns, while in 1889, 42,421 acres produced 1,271,516 bushels. According to census returns, as well as the testimony of many of the older farmers, the average yields per acre are higher than they were thirty or forty years ago. Better methods of tillage and the reclamation of many hundred of acres of the Clyde soils (black lands) are the chief factor in this increase.

For each of the three census years, 1879, 1889 and 1899, approximately 25,000 acres were sown to winter wheat, and the average yields were about 14 bushels per acre. In 1909 the acreage dropped to 9,872 and the production was 137,956, or 14 bushels per acre. While the usual acreage in recent years is undoubtedly above that just given, it would be greatly reduced were it not that many farmers prefer wheat to oats in the usual rotation of corn, wheat, (or oats) and clover. Few farmers consider the crop profitable unless returns of 20 to 30 bushels per acre are obtained.

The acreage of oats in 1909 was 33,962, compared with 16,928 in 1899 and 12,663 acres in 1889. The average yield for each of these years was very close to 35 bushels per acre, but the returns vary greatly from year to year, ranging from less than 20 bushels per acre on some farms to as high as 80 or 90 bushels on others.

The value of clover for soil improvement is generally recognized, and more or less of it is grown on practically every farm. As a rule clover and timothy are grown together, and a clear stand

*The agricultural data given in this chapter are taken from the Census reports.

of either is usually the result of one or the other failing to "catch" or to maintain itself during the period when the land is used as a meadow or pasture.

Within the last five years the total acreage of alfalfa has rapidly increased, and the experimental stage of its introduction may be said to have been passed. On many farms there are fields of 3 to 5 acres, and in a few instances, farmers have extended such small beginnings to 20 or 30 acres. Three cuttings per annum are generally made, with an average yield in most cases of about 1 ton per acre at each cutting.

The culture of soy beans has been taken up by many farmers within the last few years. Several hundred acres were planted in 1915, mostly in small acreages, although there were a few fields of 10 to 20 acres each. Various cultural methods were practiced. In some instances the seed was drilled in rows 10 or 15 inches apart, and some cultivation was given during the early period of growth. In many fields the beans were drilled solid on well-prepared ground and no cultivation was given, and occasionally the beans were planted in corn at the last cultivation. Good results have attended each of the first two methods, and returns of 30 bushels per acre have been reported. In the wet season of 1915, cultivated fields gave more satisfactory results. The crop is harvested with a mower, provided with a bunching attachment, and on becoming sufficiently dry is run through a threshing machine.

For several years past, some attention has been given to sugar beet growing. In 1915, more than 200 acres were planted, chiefly in fields ranging from 5 to 20 acres each, but on about 40 acres the crop was destroyed by the exceptionally wet weather, which caused water to stand for days at a time on some of the lowest ground. The acreage harvested yielded about 12.5 tons per acre. The beds are grown under contract with a sugar manufacturing company, one of whose plants is located at Decatur, Indiana. The company provides seed, implements and laborers, who do the hard weeding and thinning, charging so much per acre for that service. The grower prepares the ground, cultivates the crop, and delivers it to the shipping point on the railway. The cost of production varies considerably, but may be placed at a general estimate of about $25 per acre, exclusive of the grower's work and rent of land. The contract in recent years has been about $5 per ton, with a provisional increase of price if sugar goes above a certain price within four months after the beets are harvested.

Many growers had returns of 16 to 18 tons per acre in 1915. The Clyde silty clay loam is preferred for the crop, for the sugar content of beets grown on it is as high as of those raised on the Miami soils, while the tonnage is usually much greater.

Very little attention is given to truck growing. Potatoes are grown for the local market, and some seasons tomatoes are produced under contract with canning companies outside the county. Nearly every farm has a small apple orchard, in addition to many peach, plum and cherry trees, but there are only about two commercial orchards in the county.

Wheat and sugar beets are almost the only strictly sale crops. Oats is chiefly a sale crop, although much of this grain is retained on the farm for feed. By far the larger part of the corn crop is also fed at home or sold to neighboring farmers.

On nearly all farms, the sale of fattened hogs constitutes the largest single source of income. The raising of beef cattle is not very important and only a few farmers make a practice of feeding steers. Dairying is confined chiefly to the sale of milk and cream for shipment outside the county, or to a milk condenser located at Vera Cruz. There are some large, well-kept dairy farms in the county and many of the farmers near the railroads and electric lines keep a few dairy cows. There are no co-operative creameries. There are a good many small flocks of sheep, but no large flocks are kept on any farms, nor are any sheep imported to be fattened. Poultry constitutes an important source of income.

The great importance of hog raising in the agriculture of the county is shown in the U. S. Census reports. In 1909, there were 65,342 hogs sold or slaughtered, or an average of about 36 head to the farm. In that year also 2,586 calves, 4,881 other cattle and 9,619 sheep and goats were sold or slaughtered and there were 7,949 dairy cows on farms reporting dairy products. The total value of animals sold and slaughtered was $1,276,219; of dairy products, excluding home use of milk and cream, $171,184; and of poultry and eggs produced $387,881.

The adaptability of crops to soils is generally recognized in Wells County. The Clyde silty clay loam is considered especially well suited to corn, while the Miami silty clay loam and the Fox loam are considered somewhat better wheat lands than either the Clyde or the Crosby silty clay loam. Practically all cereals, grasses, and vegetables make larger average yields on the black, than on the gray soils, but as a rule the crops produced on the latter are of better quality. In the case of potatoes, tomatoes, and some

other vegetables the difference is quite marked. It is also noticeable in the case of timothy hay, and in the pasturage value of clover and grass. With respect to wheat and oats, the soil does not seem to influence the quality to any appreciable degree, except indirectly as the soil types respond differently to seasonal influences. The Miami soils, under good management, produce firm, well-matured corn of very high feeding value, while on the Clyde soils this crop tends to late maturity and is rather low in feeding value. The difference is most noticeable in grain grown on phases of the Clyde silty clay loam that approach much or have an exceptionally high content of organic matter. Apple, cherry and pear trees thrive on the Miami soils, but seem to be shorter lived on the Clyde, even in locations that are well drained.

Labor-saving machinery is in general use. It is probable that the equipment on the average farm includes as many of the latest types of agricultural implements as can be found anywhere in the corn belt. Nearly all tillage operations are performed with riding machines, and hand labor everywhere is reduced to a minimum. Heavy horses are generally used, and but few mules are employed. Very recently, several gasoline tractors have been introduced, which have been satisfactorily used for plowing. Numerous steam traction engines are employed for threshing, hulling clover and sawing wood.

Corn ground is usually plowed 5 or 6 inches deep, disced or harrowed once or twice, and the corn planted in "checks" so as to admit of cross-cultivation. Many farmers, however, prefer drilling the seed so as to have single stalks about a foot apart in the rows, a method that is quite satisfactory if the ground is free from weeds. Shallow cultivation is the rule, but the crop is "laid by" after three or four cultivations, and further tillage with a one-horse implement is seldom given. Fall plowing is not so generally practiced as would seem desirable, owing in part to the tendency of the Miami soils to "run together" if much wet weather prevails, and also to the utilization of the second-growth clover for winter pasturage where this precedes the crop. Commercial fertilizer is rarely applied to corn ground. It is more frequently used on wheat land, although the practice is not so common as in some of the counties farther west in the state.

Only winter varieties of wheat are grown. Much of the seed is drilled in corn fields, either between the rows or after the corn has been cut for fodder or ensilage. In the latter case, the ground is usually disced, but in the former no preparation is practicable.

While the type of soil, its condition at seeding time, and the subsequent seasonal conditions are the chief factors in determining yields, grain sown on ground that has been plowed rather early in the season and disced or harrowed until a suitable seed bed is prepared, usually gives the best returns. On adjoining lands in recent years, the yields have ranged from 10 to 30 bushels per acre.

Oats are almost invariably sown on land that was in corn the preceding year, the seed being drilled among the stalks. Such discing and harrowing as is done is less effective than if the ground were in better condition than is usually the case in early spring. Beyond doubt, this crop receives less cultivation than any of the other important crops. Partly from this cause and partly owing to the high moisture requirements, the yields are greatly affected by irregularities in precipitation during the spring and early summer.

A steadily increasing proportion of the farmers whose lands consist largely of the Miami and Crosby types are using commercial fertilizers. In most instances mixtures containing about 1 or 2 per cent nitrogen, 6 to 10 per cent phosphoric acid, and 3 or 4 per cent potash are applied at the rate of 200 pounds per acre. While various results have been obtained, the opinion is generally that yields are increased and the quality of grain is somewhat improved by the use of commercial fertilizer. In a few instances commercial fertilizers have been applied to corn lands, usually the Miami and Crosby silty clay loams, but no very definite results have been obtained. The growing of clover as a green-manuring crop is preferred, and recently the use of soy beans has been receiving attention. Lime as a soil amendment is used to some extent, chiefly in an experimental way by a few farmers desirous of insuring a stand of alfalfa or increased yields of clover. No raw rock phosphate or basic slag has been used.

As previously stated, the most common rotation consists of corn, followed by wheat or oats with which clover and timothy have been sowed, the latter crops usually occupying the land two years. Many farmers would eliminate the small grain entirely if a practicable method of changing land from corn to grass could be found. In the wet season of 1915, clover sown in corn fields in August or September made a good stand, and this method where late tillage is practiced, promises to be generally successful.

A very large proportion of the farms are well improved. The houses are commodious and comfortable and the barns and

buildings afford ample room and convenient means for the care of crops and live stock. Some of the smaller farms, particularly those occupied by tenants, are not so well improved, but nearly all are well fenced. In the extreme southern part of the county which lies in the oil and gas belt, agriculture has been neglected during the last twenty years and on many of the farms the improvements are comparatively poor.

Wages for farm hands range from $25 to $30 per month with board. During harvest a daily wage of $1.50 to $2.00 is paid. No marked scarcity of labor in recent years is reported.

Both the cash and share systems of rental are in use in the county. Well improved farms consisting chiefly of the Clyde silty clay loam rent for $6 to $8 an acre per annum, or for two-fifths to one-half of the grain crops, with a cash consideration for meadow and pasture lands. Many farms are operated on an equal share basis, and this plan is increasing in favor. In 1880, 80 per cent of the farms operated by the owners; in 1910 the per centage had declined to 67.4.

In 1910 there were 2,655 farms in the county, as compared with 2,884 in 1900, showing a decrease of 229 in 10 years. One thousand and eighty-one farms range in size from 50 to 99 acres. 675 include from 100 to 174 acres, and about 500 have from 20 to 49 acres. The respective group represent for the most part holdings of 80, 160 and 40 acres. Only four farms include more than 500 acres each. The average size of farms is 85.2 acres.

Farm land within a few miles of large towns or near the electric railway sells for $150 to $200 an acre, while more inaccessible land is valued at $100 to $150 an acre. Well improved farms consisting chiefly of "black" land command the highest prices.

Soils

The surface formation throughout this county is a glacial deposit of the period known as the late Wisconsin ice invasion. As exposed in road cuts this material is a light brown to pale yellowish brown till, composed chiefly of silt and clay, with only a small proporation of sand and, as a rule, comparatively few pebbles and stones. It is therefore quite compact and has a decided tendency to a granular structure below the immediate surface layer, which is very silty and friable. The stony material includes much chert, quartz, fine-grained granite, and other resistant rock, but there are also some rather soft shale fragments

and much limestone. Below 20 to 30 inches the till is highly calcareous.

On the slopes bordering the river valleys and throughout most of the depressions in which the larger creeks flow, the clayey till gives place to beds of irregularly startified sand and gravel. There are usually several feet of silty material overlying these deposits, so that there are very few surface exposures of the gravel, except on the steepest slopes. Like the till, this gravel is very calcareous.

Both the heavy till of the uplands and the gravelly deposits of the lower lands usually change at a depth of a few yards to a lighter colored and more compact glacial material. The latter is not so permeable as the overlying strata, and probably affects their drainage to some extent. This substratum also contains much lime.

The glacial deposits rest upon Niagara limestone. On the uplands the depth from the surface to this rock varies from 15 or 20 to upwards of 100 feet. In the Wabash valley and on the lower courses of some of the southern tributaries of that stream, the rock occurs at slight depths, and in a few places may be touched by the plough. Otherwise it exerts no direct influence upon the soils.

The leaching and oxidation of the surface layers of the till, the feeble erosion that the mild topography induces, combined with the effect of the original vegetal covering, has given rise to several distinct soil series.

In the depressions or wherever the natural drainage is sluggish black soils with drab subsurface and light grayish subsoils have been developed. Here the Clyde series is developed, a series of common occurrence throughout northern Indiana. Its distinctive features, the black color and granular structure, are due chiefly to the high content of organic matter. This is carbonaceous material or the residue of vegetal matter that has decomposed under the swampy conditions that formerly prevailed in these depressed areas. While nearly all the type was forested when white men entered this region, it is highly probable that in recent times, geologically considered, each area has passed through the successive stages of pond, marsh, marshy prairie, and ill-drained forest land.

Wherever the surface has a pronounced inclination, or is even slightly convex upward and therefore has effective drainage, light colored silty soils are found, with heavier subsoils in which

shades of brown or yellowish brown prevail. The more rolling areas where good drainage prevails give rise to the Miami series of soils, except distinctly morainic areas with a porous, gravelly sub-stratum, which belong in the Bellefontaine series; and the flatter areas with less perfect drainage are classed in the Crosby series. All these comparatively well drained areas were originally forested, and under such conditions organic remains do not accumulate, as in similar soils covered with herbaceous vegetables.

All of the terraces, consisting of water, deposited material, belong in the Fox series and the first bottom in the Genesee series. Muck and meadow are miscellaneous types of limited development.

The Miami series is characterized by light brownish gray surface soils and yellowish-brown, heavier and more compact subsoils, distinctly calcareous below a depth of 20 to 36 inches. In the heavier members a slight mottling occurs in the upper subsoil, but this is not so pronounced and does not extend to so great a depth as in the corresponding members of the Bradford series. The surface is undulating to rolling and there is little or no need for artificial drainage. The silty clay loam is the only member of the series developed in Wells County.

The Crosby series is developed in level to slightly undulating upland areas, generally occupying an intermediate position between the Miami and Clyde soils with respect to topography and drainage. The surface soils are light gray or light brownish gray in color, while immediately beneath there is a light ashy gray to gray and yellowish mottled layer, extending to a depth of 12 to 16 inches. The subsoils are dull yellowish brown in color, of rather heavy texture and compact structure, and distinctly calcareous below a depth of 2 feet. Artificial drainage proves beneficial in all types of the Bedfors series. The series is represented by the silty clay loam, this being the most extensive of the upland soils.

The surface soils in the Bellefontaine series are grayish brown to brown and the subsoils are yellowish brown to reddish brown. The upper part of the subsoil is heavier than the soils and more compact, but at a depth of 2 to 3 feet, beds of coarser material are encountered, consisting of sand, gravel, and larger stone fragments. A large proportion of the underlying coarser material is limestone. The surface is gently undulating to very irregular morainic and the natural drainage even more thorough than in the

Miami soils. In Wells County the series is represented by the loam member, which is very limited in extent.

The Clyde soils, developed in the slightly depressed, poorly drained areas throughout the county, are in striking contrast to the light colored soils of the foregoing series. The surface soils are dark brownish gray to black and the subsoils are drab or gray and yellowish mottled. All areas mapped in the county were classed as the silty clay loam.

The Fox series includes grayish-brown to brown surface soils and yellowish-brown to reddish-brown heavier subsoils resting upon beds of calcareous sand and gravel at shallow depth, usually less than 3 feet. They are level to gently undulating in topography and naturally well drained. In appearance the Fox and Bellefontaine soils are very familiar, but the former are confined to the terraces, where the material was water deposited, while the latter occur in the till upland, usually in areas of distinct morainic topography. One type—the Fox loam—is mapped.

The Genesee soils are brown to dark brown in the surface portion and somewhat lighter brown to grayish brown in the subsoils. They are level to slightly undulating in topography and have fair to good drainage, but are subject to occasional overflows. They are alluvial in origin, laid down by the streams along which they occur.

The term Muck is applied to areas where the soil to a depth of 12 inches or more is a true muck, or black finely divided organic remains, dark brown to black in color.

Wet bottom-land areas, generally narrow strips along some of the small streams where the texture of the soil is extremely variable are classed as Meadow.

The following table gives the names and the actual and relative extent of the several soil types mapped in Wells County:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per Cent.	Soil.	Acres.	Per Cent.
Crosby silty clay loam	90,816	38.9	Meadow.....	2,368	1.0
Clyde silty clay loam..	70,464	30.2	Muck.....	1,472	.6
Miami silty clay loam.	60,096	25.7	Bellefontaine loam.	896	.4
Genesee silt loam.....	6,592	2.8	Fox loam.....	896	.4
			Total.....	233,600	

Miami Silty Clay Loam.

The surface soil of the Miami silty clay loam is a gray to brownish gray, friable, heavy silt loam, containing a small proportion of fine sand and usually a few pebbles and very small stones. At a depth of 6 to 8 inches it changes to a pale yellowish brown silty clay loam, which at a slightly greater depth grades into a rather compact, crumbly silty clay. The subsoil, beginning at 10 to 12 inches, is a yellowish brown clay, quite compact and with a decided tendency toward a coarsely granular structure on drying. The upper part of the subsoil usually has a pronounced brownish tint, with some brownish mottling, indicative of a higher degree of oxidation of the iron content than has taken place in the lower part. The latter is lighter colored, with numerous thin flakes and specks of light gray, and is usually very compact. Where there is more than the average proportion of sand the structure throughout the 3 foot section is more open, and reddish brown tints prevail to a greater depth. This condition is usually indicated by a pronounced brownish tint on the surface soil and the presence of some gravel and a few stones. The content of organic matter is very low, except in slight depressions or where the type merges into the Clyde soils. The soil and upper subsoil are rather thoroughly leached of lime, but the lower subsoil is sufficiently calcareous to effervesce freely when tested with hydrochloric acid. The substratum, which is usually the pale yellowish brown silty clay with more or less grayish flakes, is highly calcareous, and a part of the included stony material consists of limestone fragments. There are very few large bowlders and the occurrence of small ones is generally limited to knolls and to the steeper parts of hillsides near the streams. Pebbles and small, rounded pieces of hard rocks are quite numerous in such places, but nowhere interfere with tillage operations.

This type prevails on the strongly undulating to moderately rolling areas of the uplands. The largest area is the morainic belt, extending from Vera Cruz to the northwest corner of the county, A similar ridge extends across the extreme southern part of the county and includes the long, undulating declines north of the Salamonie River. Immediately south of the latter stream, and also of the Wabash River, the type has a rather limited development. Smaller areas occur along each of the larger creeks, and there are occasionally low morainic mounds remote from any

stream on which the soil is essentially identical with that of the larger areas just described.

The surface drainage is good, but owing to the heavy structure of the subsoil the under-drainage is rather slow.

Excepting the small acreage remaining in timber and the steepest slopes near the streams, all the type is in cultivation. Owing to its naturally good drainage, many of the earliest clearings were made on this type and some fields have been in cultivation for 50 or 60 years. In many such instances where the surface is rolling the originally silty surface layer has been largely removed by erosion, and the compact subsurface thus brought above the plow line is neither so easily tilled nor so retentive of moisture as the typical surface soil. Where the content of sand in soil and subsoil is somewhat above the average, the loss of some of the silty surface is not so apparent, for the subsurface yields more easily to tillage and its absorbtive capacity lessens the liability to injury of crops during short droughts.

The Miami silty clay loam is used largely in the production of corn, oats, hay and wheat. It is considered a good wheat soil, and yields 30 bushels per acre are often obtained. In most instances such favorable returns are obtained by thorough preparation of the soil and rather liberal fertilization. The average yield is below 20 bushels per acre.

Oats do well in normal seasons and are less liable to lodge in wet ones than on the Clyde soils. In dry years the yields is invariably reduced on land that has been cropped several successive years or otherwise poorly managed.

The suitability of the type for corn is largely determined by the amount of organic matter in the soil. Where this important element is supplied, by applying stable manure or turning under clover yields of 60 to 70 bushels per acre are very frequently obtained. The average yield is less than 40 bushels per acre.

As a rule, little trouble is experienced in obtaining a stand of clover or timothy, especially if wheat or rye is used as the nurse crop and no exceptionally dry weather occurs in July or August. Clover generally maintains itself several years and "clover sickness" is unknown. No difficulty due to acidity is reported. The abundance of lime in the subsoil doubtless accounts for the manner on which most legumes thrive on this type.

Tomatoes and other garden vegetables do not make so heavy a growth as on the darker colored soils, but the quality of the product is good.

Many of the oldest apple orchards in the county are located on this type, and it is well suited to tree fruits of all kinds.

Commercial fertilizers are used to some extent on this type, principally in connection with the corn and wheat crops.

The present market value of the type ranges from $115 to $175 an acre.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Miami silty clay loam are given:

MECHANICAL ANALYSIS OF MIAMI SILTY CLAY LOAM. WELLS COUNTY, IND.

No.	Locality.	Description.	Organic matter.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
282204	3 mi. E. of Bluffton	Silt loam, 0-6 ins.	.....	1.0	3.9	2.3	7.6	7.4	55.2	22.2
282205	Subsoil of 282204..	Silt loam to silty clay loam, 6-12 in	.....	1.0	1.8	1.2	4.4	5.2	45.1	41.2
282206	Subsoil.... under 05.	Silty clay loam, 12-36 ins.	.....	1.2	1.4	1.0	4.7	4.9	39.5	47.2

Crosby Silt Clay Loam.

The Crosby silty clay loam to a depth of 5 to 8 inches is a light gray or light brownish gray medium to heavy silt loam, grading into a light gray and yellish mottled, somewhat plastic silty clay loam. At a depth of 10 to 12 inches the subsoil becomes a yellowish brown, plastic silty clay loam to silty clay, with some gray mottlings, while below a depth of about 18 inches it is a dull, yellowish brown, very tough, plastic clay. The surface soil, except in areas grading toward the Clyde silty clay loam is very deficient in organic matter and of compact structure. The granular feel usually noticeable when a dry sample is handled, is due to sand grains and very small concretions of ferruginous material. There seems to be deficiency of time in the surface soil

and upper subsoil, but the lower subsoil, usually at below 24 to 30 inches, is highly calcareous.

The Crosby silty clay loam occurs in all sections of the county. Throughout its extent, it is intimately associated with the Clyde silty clay loam, and its elevation is only slightly higher than that of the Clyde areas.

The topography in general is very gently undulating, with occasional low ridges of somewhat stronger relief. As the streams are approached, the slopes are generally long and gentle, although occasional steeper gradients occur. Bordering the valleys of the small creeks the declivities are short and sharp, and where of sufficient size, such areas were mapped as the Miami silty clay loam.

While nearly all this type has good surface drainage and the structure of the subsoil and substratum admits of relatively free aeration and drainage, the latter would be facilitated and other conditions improved by tile drains. The general extension of the drainage lines in the adjacent areas of Clyde silty clay loam would greatly increase the ability of Crosby silty clay loam to endure dry weather as well as periods of exceptional rainfall. But few tile drains have been laid in this type.

Areas of small extent in which the silty soils is very loose and floury when dry, but inclined to pack after rains are locally referred to as "post oak" knolls and "beech flats." The subsoil in such places is usually quite compact, and the prevalence of pale, yellowish tints with much gray or bluish gray mottling indicates slow water movement and ineffective aeration.

In point of extent, as well as of agricultural value, the Crosby silty clay loam is one of the most important types of the county. It is nearly all under cultivation and used mainly for the production of corn, oats, hay and wheat. The ordinary yields are possibly a little higher than those of the Miami silty clay loam.

Nearly all the commercial fertilizer used in this county is applied to this type and the Miami silty clay loam. Most of the brands used, carry from 8 to 10 per cent of phosphoric acid, 1 or 2 per cent of nitrogen, and about 3 or 4 per cent of potash, and the resulting increase in yields seems to be due chiefly to the phosphoric acid. In very few cases, however, has the acid phosphate been used alone. The glacial material, of which the Crosby soils are practically the surface expression, is rich in potash.

That light applications of this element prove beneficial to

wheat is due in many instances to the unfavorable physical condition of the soil at the time of seeding. This is probably the reason that such fertilization is not considered necessary on the Clyde soils. Their higher per centage of organic matter, crumbly structure, and more equable moisture content favor an increase in the availability of the mineral elements.

Under the usual methods of handling the Crosby silty clay loam, the content of organic matter is too low to render the use of raw rock phosphate advisable.

The present price of this type ranges from $125 to $150 an acre.

Since several varieties of clover, including the red, mamoth, alsike, and small white, are easily grown on this soil, the maintenance of organic matter and increase of nitrogen by this familiar means is chiefly a question of soil management. The lack of lime in the surface and its abundance at a comparatively slight depth, suggests efficient cultural methods, tile drainage, and frequent changes to clover or deeper rooted leguminous crops rather than the direct application of crushed limestone. The latter may be advisable in some instances, but until such material becomes available at a very low price, its general use would not be profitable.

In sections 16 and 17, Township 25 N., and Range 10 E. (Jackson Township) a very heavy variation of the Crosby silty clay loam occurs. The surface soil is a light brownish gray silty clay loam, somewhat granular, and inclined to crack at the surface on drying. The subsoil is heavier than typical, and in the lower part is usually a stiff, drab, or mottled brown and drab clay.

The topography is nearly level and the type lies slightly lower than the adjoining Miami soils.

Results of mechanical analyses of samples of the soil and subsoil of the Crosby silty clay loam are given in the following table:

MECHANICAL ANALYSIS OF CROSBY SILTY CLAY LOAM.
WELLS COUNTY, IND.

No.	Locality.	Description.	Organic matter.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
282201	½ mi. W. of Tocsin....	Silt loam,.... 0-6 ins.....	.....	0.4	1.8	0.9	3.4	8.0	68.7	16.8
282202	Subsoil of 282201..	Silt loam,.... 6-12 ins.....	.....	.1	.6	.4	1.8.	8.3	62.6	26.1
282203	Subsoil.... under 02..	Silty clay loam, 12-36 ins.....	.....	.1	.3	.2	2.5	9.6	56.1	31.1

Clyde Silty Clay Loam.

The surface soil of the Clyde silty clay loam consists of a black, granular silty clay loam or silty clay, changing at a depth of 6 to 8 inches to a drab silty clay of less friable structure. This is generally underlain at a depth of 15 to 20 inches by a smooth, somewhat tenacious, light-colored clay, slightly mottled with yellowish brown iron stains. Underlying most of the type is a substratum of the brownish till which characterizes all the upland soils, but in the vicinity of drainage courses, a bed of gravel usually occurs at a depth of a few feet. The surface soil has a high content of organic matter, consisting mostly of old carbonaceous material, which imparts a fine physical structure to what would otherwise be a heavy soil, strongly inclined to become compact with a continued tillage. The content of organic matter is usually highest in the surface soil of the largest areas and of those that form the rather ill-defined valleys of small streams. Small areas usually include much gray silty material, having only a moderately high percentage of organic matter. According to the litmus-paper test, the upper half of the 3-foot section generally is neutral, while the lower half is calcareous, though not to such a degree as the lower subsoil of the Miami silt loam. There seems to be a more equable distribution of the lime throughout the Clyde material than in the Miami and Crosby soils.

The Clyde silty clay loam owes its origin chiefly to obstructed drainage and is confined mainly to depressions and poorly drained flats. The topography is level to gently undulating. The natural deficiency in drainage had been remedied by the construction of innumerable mains and the installation of thousands of rods of tile drains. The former high average level of the ground water which usually is indicated by the depth at which the light colored clay occurs, has been permanently lowered, although there is much local variation in this respect. In the smaller areas on the uplands, the water table may be somewhat nearer the surface than on the adjoining higher lands, but the difference is seldom of importance agriculturally. In the larger acreas the average ground water level is usually much higher. Wherever gravel is found at shallow depths, the permanent water table may be within 1 or 2 yards of the surface, or practically at the same level as water in the nearby ditches. The structure of the subsoil admits of good capillarity between these underground supplies and the surface soil. In many instances the drains lack the capacity for as prompt removal of excess surface water as is necessary in very wet seasons. This was apparent in 1915, when the crops in many low places were destroyed by ponded water.

A variation of this type having a black, waxy subsoil is encountered in many of the larger areas, but fortunately is limited to small spots, the largest of which are only a few acres in extent. In the southwestern part of the county, this variation is of more common occurrence than in the northern townships. It is locally termed "gumbo" and "blackjack," but hardly warrants such designations. The condition is due to a high per centage of clay particles in the subsoil.

On the lower courses of Eight Mile Creek, Rock Creek, and several of the other small streams, the type contains an appreciable proportion of sand and some scattered pebbles, and is somewhat coarser textured and more easily tilled than in other places.

The greater part of this type is in cultivation, the remainder being in woodlots and blue grass pastures. Practically all crops requiring a soil rich in nitrogen and high in available moisture do well on the Clyde silty clay loam. The soil is especially well suited to corn and is used very largely in its production. A yield of 100 bushels per acre has been obtained under ordinary field conditions, though the average yield is between 50 and 70 bushels. Wheat and oats make good yields, but in seasons of excessive rainfall, harvesting may be difficult on account of a rank

growth of straw and the softness of the ground. Timothy and clover seldom fail to make a uniformly good stand, and the growth is heavier than on the light colored soils. Alfalfa does well wherever grown on this type, but those areas underlain by water and having a gravel substratum at a depth of a few feet furnish ideal conditions for this plant. Such minor crops as soy beans, potatoes, and tomatoes make very satisfactory yields where good culture is given, and the type is preferred for cuch crops.

As a rule, grains and vegetables produced on this type are of somewhat poorer quality than those grown on the light colored soils. Usually the ripening period is somewhat delayed, and in the case of corn, this sometimes involves considerable risk from frost. On the other hand, where drainage is good and other conditions similar, the soil warms up earlier in the spring than the light gray soils.

No commercial fertilizer is used on the Clyde silty clay loam, except in the case of small patches planted to truck crops, and of the small areas included with the Miami silty loam, where separate treatment is impracticable. Little or no stable manure is used, the limited supply available on most farms being applied exclusively to the higher lying soils.

There are occasional small areas, rarely more than a fraction of an acre in extent, where wheat and oats fail to mature, regardless of cultural methods and seasonable conditions. A careful examination of several such spots failed to reveal any abnormal physical condition sufficient to account for the trouble. No injury to other crops is ever apparent and corn does well in such places. This latter fact is somewhat remarkable, for on the Clyde soils and associated muck lands in other sections of the state there are similar spots where the corn plants turn yellow and suffer from root rot to such an extent that little if any matured corn is obtained without heavy applications of barnyard manure or the use of potash salts.

Where the content of organic matter is exceptionally high the soil endures careless handling with far less injury than in those places that are not so rich in humus. In many fields that have been cultivated thirty or forty years, the effect of a decreasing organic-matter content is indicated by the tendency of the soil to become cloddy and to respond less satisfactorily to tillage than formerly. This condition becomes more pronounced as the black carbonaceous material decreases, for it is chiefly the latter that imparts the crumbly condition to the surface soil and the

checked or granular structure to the upper subsoil. The proportion of clay in these zones is about 30 and 35 per cent, respectively, sufficient to make a very heavy, adhesive soil were it not for the ameliorating influence of the included organic matter. The conservation of this soil constituent is quite as important as although of less immediate interest than its maintenance in the light-colored soils by plowing under clover crops.

The tillage conditions are invariably improved by fall plowing, especially in those areas that have the stiff, waxy subsurface. While the frequent alternations of freezing and thawing thus induced increase the friability of the surface soil, some loss of the finest soils constituents, both mineral and organic, by surface wash, may result unless a cover crop of some kind is grown.

The use of lime tends to hasten exhaustion of organic matter. The ample supplies of this mineral in the subsoil is sufficient for all crops under reasonable conditions of tillage.

The present price of farm land, which consists chiefly of this type, ranges from about $150 to $175 an acre.

Bellefontaine Loam.

The surface soil of the Bellefontaine loam to a depth of 12 to 15 inches is a brown to reddish brown loam or sandy loam. There is considerable textural variation, and as a rule the more sandy areas have a distinctly brown color and carry more stony material than the lighter colored silty areas. The upper subsoil is usually a brownish loam or clay loam, containing enough coarse sand to give it a gritty feel. The proportion of sand and gravel increases with depth, and the lower part of the 3 foot section is generally a dark reddish brown, sticky clay, with coarse material ranging from sand to small stones. The substratum consists of loose sand and gravel.

This type is found near the Salamonie and Wabash Rivers. The small areas near the Salamonie River consists of low ridges of such irregular shape and hummocky topography as to readily suggest their morainic character. Those near the Wabash River and on the lower course of Rock Creek are not so clearly differentiated from the surrounding uplands.

Owing to the presence of the gravel at slight depths, a part of the type is inclined to be droughty, but in most instances the depth of loam is sufficient to retain enough moisture to carry crops to maturity.

All of the areas of this type are in cultivation. Wheat and clover do well in most years, but corn and oars give best returns in seasons of liberal rainfall.

Fox Loam

The surface soil of the Fox loam is a friable loam to a silt loam, with a variable proportion of course sand and pebbles. The color of the silty soil is gray to brown, while that of the more sandy material is a pronounced brown. In all instances the content of organic matter is low.

No very definite line can be drawn between the soil and subsoil, but at a depth of 10 to 15 inches the latter is usually a stiff clay loam, changing with increase of depth to a dark reddish brown gravelly clay in which the coarse material may be so abundant that it cannot be penetrated with a soil auger. In such cases the substratum consists of irregularly stratified sand and gravel.

Where the surface soil is a gray, silty loam, the upper subsoil is generally a compact, yeollwish silty clay loam, and the depth to gravel may be several feet below the surface.

The type has an inextensive development in this county. The largest areas occur on the terraces of the Wabash River, but none of the latter include more than 150 acres. Their elevation above the adjacent bottom lands ranges from 10 to 25 feet, and their surface configuration varies from level to gently undulating. The areas near Markle is a gently sloping belt of sandy land between the low hills to the south and the narrow river bottoms on the north. The other small areas in this locality, both with respect to soil and physiographic position, are rather broad transitions from the upland to the bottom lands. The areas on lower Eight Mile Creek are bench lands, rising 15 to 20 feet above the stream. The developments elsewhere are gravelly deposits with a variable depth of sandy loam and loam. The areas on Rock Creek, some of which are too small to be mapped, have a soil resembling the lighter variations of the Miami silty clay loam. The small areas near the Salamonie River are essentially gravel deposits on the outer side of the curves. The soil is a brown loam to sandy loam and generally inclined to be droughty.

All these areas are in cultivation and good yields of corn, clover, oats, and wheat are usually obtained. The latter does exceptionally well on the heavier soil. The sandy areas with

loose gravel at a depth of 2 to 3 feet are, of course, susceptible to dry weather, but these constitute but a small proportion of the type.

All this type may be worked sooner after rains than the adjoining upland soils. The soil is acid and the subsoil does not usually contain much lime, although a large per centage of the underlying gravelly material is limestone.

Genesee Silt Loam.

The Genesee silt loam, as developed in the Wabash valley, consists of a brown silt loam, 12 to 15 inches deep, underlain by a dark brown and gray mottled silt loam to silty clay loam, which at a depth of 2 or 3 feet usually grades into coarse sandy loam. There is considerable variation in the texture of the surface soil, chiefly with respect to the proportion of sand. In many places it is a sandy loam of slightly reddish brown color. In such places the subsoil is generally a brown sandy loam underlain by gravel. In the slightly depressed areas along the foot of the hillsides, the soil is a dark colored silt loam with a rather heavy subsoil. Between Murray and Markle this heavy alluvium is quite common occurrence and the underlying limestone is within a few feet of the surface at some points. Also near Barber Mill, on Rock Creek, a dark colored, heavy soil occurs, and near the village the limestone is frequently found within 3 feet of the surface.

In the Salamonie valley, the type is generally heavier and darker colored than along the Wabash River. The slightly elevated parts of the alluvial deposits are somewhat sandy, but in the depressions the soil is a rather crumbly silt loam or silty clay loam containing considerable organic matter.

The type, as developed along the lower courses of the small streams, is a dark silty loam to silty clay loam, in many places practically identical with the lighter portions of the Clyde silty clay loam.

All of the type is subject to overflow, but the floods in the river valleys usually occur early in the season. In 1915, exceptionally high waters in July and August destroyed the crops on the lower parts of the bottom lands of the Salamonie River, Rock Creek, and other small streams. A large proportion of the Genesee silt loam along the Wabash lies so high that the injury to crops was not great. Such destructive midsummer floods had not occurred since 1875.

Nearly all the type is cleared. Oats and clover do well, but most of the land is devoted to corn, with rather irregular alternations to small grains or grass crops. In favorable seasons, yields of 50 to 60 bushels per acre are obtained on the sandy areas, while the silty areas often produce higher yields.

Muck.

The largest area of Muck in Wells County lies along upper Eight Mile Creek, in Jefferson Township. It forms a nearly continuous border generally less than one-fourth miles wide, on each side of the channel from the east boundary of the county to Ossian.

In this area the Muck consists of black, finely divided vegetal remains without much earthy material in the surface portion, except where silt has been deposited by overflow water from the streams or washed from the higher lands. In places there is considerable rotten and partially carbonized wood, and where the accumulations are deepest, as in the section east of Tocsin, the lower part of the material is somewhat peaty. The depth seldom exceeds 3 or 4 feet, and the average is much less. There has been much settling of this area in recent years, and in sections 31 and 32, Township 28, Range 13 East, the surface material to a depth of several feet was burned about 16 years ago. Farther down the stream smaller areas have been similarly reduced in depth at various times. The substratum, so far as observations could be made, seems to consist throughout of a stiff, light-colored clay, rich in lime.

The channel of Eight Mile Creek has been straightened and deepened, so that it affords a good outlet for the numerous ditches and tile drains by which the Muck and adjoining Clyde silty clay loam have been reclaimed.

The next largest area of Muck is that south of Bluffton, on Prairie Ditch. It was originally a marsh, but it is now well drained. The material in this area is generally from 1 to 3 feet in depth and is underlain by clay. In places, the latter is very calcareous a little below its contact with the overlying vegetable remains.

The small areas in other parts of the county are essentially the same as that just described. The soil is of variable depth, usually grading from a few inches of silty Muck at the margin, to nearly clear carbonaceous material at the center, which may have a depth of several feet.

The surface layer of all the Muck areas is acid, according to tests with litmus paper.

Nearly all of the Muck is under cultivation, with corn as the main crop. Corn does well, although there is liability to injury by overflows and late frosts. The quality of the grain is not so good, especially in wet seasons as that on the uplands.

On Muck and Peat soils in other areas corn usually is more or less affected by some disease that causes the roots to rot and the foliage to turn yellow, but in this county, such injury has not occurred to any appreciable extent. Where several feet of the original surface has been burned it is possible that the potash thus released acts as an amendment similar to the muriate or sulphate of potash that is often applied to mucky soils as a corrective of this trouble, but this does not explain the fact that all the Muck in Wells County is singularly free from this cause of injury to corn[1].

Red and alsike clovers usually make a rank growth, but the lower part of the stems often rot and the quality of hay is thus injured.

Oats are not usually sown in Muck, for if the season is wet it is almost impossible to satisfactorily harvest them. Wheat is less inclined to lodge, and on the shallower areas usually does well in dry years.

Excellent yields of rye and barley have been reported, and the ordinary yields of the limited acreages grown are higher than on any other soils in the county.

In a few instances, alfalfa has been successfully grown on the shallower areas of Muck. Considering the abundance of nitrogen, the calcareous nature of the clay subsoil, and the high average level of the water table in well drained places, it seems that alfalfa should thrive on the shallower areas of this type. On the deeper areas the looseness of the soil and the somewhat uncertain moisture conditions might prove unsuitable for this crop.

In some places it is probable that the water supply could be controlled by damming the ditches or installing some form of pumping plant and a limited acreage thus rendered highly suitable for celery, onions, and cabbage.

The area shown as Muck around Twin Lakes in sections 22 and 23, Jackson Township, is really a good development of Peat, but it is too small to show as a separate type. It is the bed of a small lake that was drained a few years ago, and also forms the margin of a rather deep pond nearby. The soil consists chiefly of

1. See Description of Muck in Soil Survey report on Boone County, Indiana.

brown, fibrous material in which the partially decomposed remains of aquatic plants are still abundant. Excepting the margin, which is in part Muck and also includes a few acres of black sandy loam, this area has very little agricultural value.

Meadow.

Meadow represents the variable soil conditions encountered in the narrow, trough-like valleys of the larger creeks. It consists of alluvial material, chiefly silt, but there is more or less sand, especially near the channels, and the soil varies from sandy loams to heavy silty loams, the latter predominating. As a rule, the surface is quite uneven, there being sections of abondoned channels and ill-drained spots at the foot of the slopes, so that cultivation is inconvenient. Most of such land is used only for pastures.

The low strips of alluvium along the Salamonie River that were mapped as Meadow are so frequently over-flowed that very little of their area is tillable. In most instances they are covered with trees, underbrush, and weeds. On the Wabash River there is very little alluvium that can be classed with Meadow.

Summary.

Wells County is situated in the northeastern part of Indiana and embraces an area of 367 square miles, or 234,880 acres. The greater part of the surface is a somewhat uneven plain having an elevation of about 850 feet above sea level. The topography is undulating to rolling. Practically all of the surface is tillable, with the exception of the steep acclivities that bound the stream valleys and the very small areas of Muck and Peat.

The rivers and larger creeks of the county follow a general course from southeast to northwest, but many of the minor streams flow from southwest to northeast.

The 1910 census reports the population of the county as 22,418, of which 77.8 per cent is classed as rural. The population of Bluffton, the county seat and largest town, was 4,987, and that of Ossian, the next largest town, 661. The greater part of the county is well served by steam and electric railroads, and the public roads and market facilities are good. Most every farmhouse has telephone and rural free delivery of mail service.

The climate of the county is comparatively uniform. The mean annual temperature at Bluffton is 50 degrees F., and the mean annual precipitation is 36.94 inches, the greater part of

which falls during the spring and summer months. There is a normal growing season of 148 days.

Corn, wheat, oats, and clover are the principal crops grown in Wells County. Alfalfa, soy beans, and sugar beets are grown to some extent. Wheat and sugar beets are about the only strictly sale crops. Oats is chiefly a sale crop, although much of the grain is fed on the farms. By far the larger part of the corn is also fed at home or sold in the county. Hog raising is the chief animal industry and is very important. In 1909 there were 65,342 hogs sold or slaughtered, or an average of about 36 head per farm. Comparatively few cattle are fattened and dairying has not been extensively developed.

In 1909 there were 2,884 farms in the county and in 1910 the number had decreased to 2,655. The average size of farms is 85.2 acres. The price of farm land ranges from $100 to $200 an acre.

Exclusive of the miscellaneous classifications, Muck and Meadow, the soils of the county are grouped in six series, in each of which one type is mapped. Three types, the Miami, Crosby, and Clyde silty clay loam, constitute the greater part of the area surveyed.

The Miami silty clay loam is a well-drained, light colored type, well suited to general farming, but has not the high productive capacity that characterizes the Clyde silty clay loam.

The Crosby silty clay loam also is a light colored type, occupying flat to gently undulating topography. It is less perfectly drained than the Miami silty clay loam. Corn, oats and hay are the important crops.

The Clyde silty clay loam is a black soil very well suited to corn and clover.

The Bellefontaine loam is a brown upland soil underlain by gravel. The Fox loam is a similar type occuring on the terraces of the larger streams. Both are inextensively developed. They are used for the general crops and give good yields.

The Geneses silt loam includes all the safely tillable alluvial soil. Corn is the chief crop and usually heavy yields are obtained.

Meadow embraces alluvial deposits of low agricultural value on account of liability to frequent overflows.

The several areas of Muck mapped in the county are artificially drained and devoted chiefly to corn, clover and timothy.

Soil Survey of Grant County, Indiana.

By L. A. Hurst, In Charge, W. I. Watkins, and W. E. Tharp, of the U. S. Department of Agriculture, and Earl Hertenstein and Philip Middleton, of the State of Indiana Department of Geology.

DESCRIPTION OF THE AREA

Grant County, with an area 418 square miles, or 270,720 acres, is located somewhat north and east of the geographic center of Indiana. It is a rectangle in outline, and is 19 miles wide from north to south and 22 miles long from east to west. It is bordered by nine counties, Wabash and Huntington on the north, Wells and Blackford on the east, Delaware and Madison on the south, and Tipton, Howard, and Miami on the west.

The surface of the county is essentially a plain, dissected by the Mississinewa River and its many tributaries. The only surface relief developed is due to the gradual deepening of the various stream valleys and gullies and the constant lowering of the surface by erosion. Hence, the rougher topography occurs in the vicinity of the stream courses, particularly along the Mississinewa River and along the larger creeks, which have cut their valleys 50 to 100 feet deep through the glacial drift to the river level. The topography here may be described as undulating to hilly, although the crests of the hills are on a level with the plains back from the river. The western, southwestern, eastern, and northeastern parts of the county are comparatively level. The central and northern portions are more broken and are naturally better drained.

The elevations of the county range from 805 feet above sea level at Marion to 939 feet at Upland, the average elevation being approximately 845 feet. Swayzee, in the western part of the county, has an elevation of 862 feet; and Fairmount, in the southern part, an altitude of 880 feet. Van Buren, in the northwestern part, is 842 feet above sea level.

The Mississinewa River and its tributaries form the main

drainage system of the county. The river enters the county at the southeastern corner and traverses it in a general northwesterly course. The chief tributaries include Jocinah, Hummel, Lugar, and Walnut Creeks on the east, and Deer, Boots, and Catt Creeks on the west. Black and Little Black Creeks drain the northeastern portion of the county, and Grassy and Middlefork Creeks the southwestern part. Pipe Creek and Taylor Creek, its main tributary, drain the western and northwestern parts and flow in a general northwesterly course out of the county. Many of these streams head in former lake beds, ponded areas, or old filled-in valleys which were formerly in a semi-swampy condition. By means of dredging, the original winding and sluggish watercourses have been converted into deep and comparatively straight channels which form the main outlets for the poorly drained sections of the county.

The first white settlers in the territory now included in Grant County, came chiefly from North and South Carolina and Ohio. The county was in 1831. From that time forward there was a steady growth in population until 1900, since which year a decline has taken place. The census of 1880 gave the total population as 23,618. The discovery of natural gas in 1887 caused a rapid growth of the towns, and the census of 1900 reports 54,693 inhabitants, as compared with 51,426, reported in 1910. The falling off in population is attributable not so much to a change in rural as in industrial conditions. Upon the depletion of the natural-gas supply, which afforded cheap fuel, some of the factories in various towns throughout the county ceased operations, although many important plants are still operated. Natural gas is at present used chiefly by the farmers for domestic purposes, and is not available in sufficient quantity to supply the needs of the city of Marion and the other towns of the county.

The rural population of Grant County comprises 51.2 per cent of the total, the inhabitants of towns of less than 2,500 population being classed as rural by the census. The 1910 census reports the total population in the various towns and villages of the county outside of Marion as 14,030, and the farming population is thus placed at 18,037. The combined population of Marion and the smaller towns and villages is almost double the farming population.

Marion, the county seat, with a population of 19,359, is the largest town in Grant County. It is situated on the Mississinewa River, near the center of the county. It is the center of a rich

agricultural region and has a number of manufactories. Gas City, Fairmount, Jonesboro, Van Buren, and Upland are other important towns, shipping and trading centers for the rich agricultural territory surrounding them. These towns also have manufacturing interests. There are a number of small towns and villages throughout the county.

The first railroad, the Pennsylvania line, was constructed through Marion in 1868, and the Cincinnati & Wabash & Michigan (now the Big Four) in 1875. Since then two other railroad lines have been built and the county has adequate transportation and shipping facilities in all sections, being served by four trunk lines of steam railroad and two electric lines. The county has good traffic connections with Indianapolis, Logansport, Muncie, Chicago, Cincinnati, and other large cities.

Toll roads, such as the Strawtown, Jonesboro, Delphi, Huntington, Bradford, Salem, and Wabash, Pikes connecting the principal towns, were the first improved highway. Within recent years the pikes have been opened by the county to public use and supplemented by an excellent sectionized public-road system, giving every farm easy access to towns, markets, schools, and churches. Gravel is abundant for constructing and repairing the roads and very few miles of unimproved road remain, most of the highways having been surfaced with this material and put in excellent condition. Some macadamized roads have been built in recent years and at the time of the survey surfacing with a commercial preparation was becoming general. The streams are spanned by modern steel bridges.

The principal markets for produce sold outside the county are Indianapolis, Chicago, and Cincinnati, Marion is 69 miles from Indianapolis and 151 miles from Chicago.

Climate.

The data shown in the table below, giving the normal and extreme temperature and precipitation by months and seasons, and for the year, are compiled from the Weather Bureau records kept at Marion, and are representative of the climatic conditions throughout the county.

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT MARION.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1892).	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	30.7	66	—12	2.44	3.27	1.60	5.3
January	26.9	68	—25	2.47	1.84	1.41	9.0
February	26.4	67	—20	2.30	0.51	3.21	7.7
Winter	28.0	68	—25	7.21	5.62	6.22	22.0
March	38.7	85	— 2	3.51	2.16	2.87	6.1
April	50.7	89	17	3.14	1.71	5.63	1.1
May	61.2	96	26	3.96	0.81	10.65	0.1
Spring	50.1	96	— 2	10.61	4.68	19.15	7.3
June	70.2	100	35	4.21	1.37	7.52	.....
July	74.2	105	37	2.89	0.80	6.18	.....
August	72.3	101	40	3.10	1.37	5.46	.....
Summer	72.2	105	35	10.20	3.54	19.16	.....
September	66.0	101	29	2.95	2.46	5.53	.....
October	53.9	91	15	2.02	0.91	T.	0.1
November	39.9	75	2	3.13	5.42	4.52	2.0
Fall	53.0	101	2	8.10	8.79	10.05	2.1
Year	50.9	105	—25	36.12	22.63	54.58	31.4

The county is not subject to frequent occurrences of marked extremes of heat or cold. High temperatures are not uncommon in July, August, and September, but are seldom of long duration except when accompanied by extremely dry weather. Snow in severe winters, sometimes lasts for several weeks, but usually the ground remains frozen only a few weeks, and a general thaw is expected in February or March.

The average annual rainfall of 36.12 inches is so uniformly dis-

tributed throughout the year that neither extreme drought nor excessive rain is common, except at the time of the annual freshets, which usually come in the early spring. May and June generally have the greatest rainfall. The average annual fall of snow is 31.4. inches.

The length of the average growing season is about 5 months. The average date of the last killing frost in spring and of its first in autumn are May 9 and October 4, respectively. The earliest recorded killing frost in autumn occurred September 5, and the latest in spring, June 7.

Agriculture.

Agriculture in Grant County began with the planting of small patches of maize and other crops by the Indians, but real development dates from the time the white immigrants, an agricultural people, began to clear and improve their homesteads. Progress was necessarily slow because of the lack of capital, labor-saving implements, and adequate facilities for clearing and draining the land, and the absence of markets and roads. The early settlers found the land covered with a dense growth of hardwood, interrupted only occasionally by an open, swampy prairie; small woodlot pastures of 10 to 40 acres upon the average farm are all that remains of the forest growth. Much of the forested area also was in a poorly drained condition throughout the greater part of the year. The lack of drainage outlets and the cost of installing artificial drainage in the wet areas prohibited their use for cultivation, and for several decades after the first settlements were made only land having good natural drainage could be cultivated. For this reason, the rolling lands near the Mississinewa River and the larger creeks were the first to be homesteaded. The rich alluvial lands, productive of large yields of corn, were a further inducement to the early settlers to locate near the river, which by the use of rafts or flatboats gave access to outside markets. The clay, soils of the uplands were better suited to wheat and oats and were utilized largely for the growing of these crops. Corn, wheat, oats, rye, flax, and potatoes were important among the early crops grown in the county. Hay was cut from the open prairie.

The development of the county was very gradual until the late seventies or early eighties, when the so-called black lands or wet areas became available for cultivation through the installation of adequate drainage outlets, the channels of the smaller creeks and branches being deepened, straightened, and widened

to serve as such. The drainage of individual farms was effected through open ditches, but the disadvantage of having the fields cut up with ditches led later to the laying of tile drains. Thousands of dollars have been expended for drainage, but the rapid increase in land values has offset the expense many times, the rise in price being commensurate with the increased crop yields. Land values have advanced from about $40 an acre in 1880, to $100 and $200 or more an acre at the present time. The building of improved roads, the construction of good farm buildings, schools and churches, and the excellent shipping and marketing facilities have all contributed to this advance in land values.

Corn, oats, and wheat are at present, as in the past, the staple crops of the county. Corn has always been the leading crop. Wheat remained second in order of production until after 1900, the 1910 census showing a production of oats nearly 3½ times that of wheat. The total value of all cereals produced in 1909 is reported by the census as $2,285,952.

The census statistics from 1850 to 1910 show a steady increase in the production of corn from 361,318 bushels in 1849 to 3,299,221 bushels in 1909. No acreage statistics are available for census years previous to 1880, but beginning with that period the average yield per acre has been 32, 30.1, 43.8, and 49 bushels, respectively, for each succeeding year. The increase in production is due for the most part to the higher yields obtained from the "black lands," which have contributed a large percentage of the increase in acreage from 47,871 acres in 1879 to 67,391 acres in 1909. Careful seed selection and better cultural methods have also contributed to the increase in corn yields. The average yield of corn per acre for 1914 is reported by the county agricultural agent as 40 bushels. It is estimated that the "black lands" yield on an average, 10 to 20 bushels per acre more than the "clay lands." As corn is the most profitable of the cereal crops, naturally more attention is given to its production than to that of other crops. Without the large production of corn, the $1,683,609 of revenue received from the sale or slaughter of live stock, as shown by the 1910 census, would hardly be possible or would at least represent a smaller proportion of profit. It is estimated by the county agricultural agent that two-thirds of the corn crop is fed locally, three-fourths of the quantity used for local feeding, being confined to hogs. The tendency is to limit the production of corn only by the acreage of land adapted to its requirements.

The production of oats is now next to that of corn, the crop of 1909 being nearly $3\frac{1}{2}$ times as large as that of wheat, which up to about 1900 exceeded oats in production. In the period from 1849 to 1909, the production of oats increased from 40,973 bushels to 985,806 bushels, or more than 24-fold, this increase being nearly 3 times the proportionate increase in corn production for the same period. The fluctuation in the acreage yield of oats has been less than $2\frac{1}{2}$ bushels in the four census years from 1879 to 1909, the yields being 31.6, 30.2, 32.6, and 32.2. bushels per acre, respectively. The effect of the increase in the cultivated acreage of "black land" has been to increase the production of corn rather than that of oats. One reason why the "black lands" are given preference for corn is that a much larger proportion of the oat crop is destroyed by lodging upon these lands than upon the lighter soils. Oats have never been rated as a money-making crop, but they fit in well with the customary rotation and are especially valued for the straw, which is used as bedding for stock or is baled and sold to the strawboard mill at Marion. The grain is used to some extent locally or on the farm where grown, for feed, but the bulk of it is disposed of at the grain elevators situated in all parts of the county. The introduction of cowpeas, soy beans, and alfalfa should tend to decrease the acreage of oats and wheat in the future, since these legumes will to an extent supplant clover, for which oats and wheat, especially the latter, have been largely grown as nurse crops.

The acreage in wheat remained fairly constant from 1880 to 1900, so far as shown at the three census periods included, the area in wheat being 30,783 acres in 1879, 32,823 in 1889, and 29,396 in 1899. The 1910 census shows a sudden decrease to 16,840 acres in 1909. The average yield per acre as shown by the census reports is so variable as to admit of no definite deductions regarding a general increase or decrease in yield from 1880 to 1910. The average yield in the four census years was 20, 12, 8, 7, and 17 bushels, respectively. It is generally considered that there has been a gradual decline in the average yield of wheat except where commercial fertilizers have been used. The use of wheat as a winter cover crop and as a nurse crop for clover warrants its retention in the usual rotation of corn, wheat or oats, and clover, but commercially wheat is generally rated as unprofitable where less than 20 or 30 bushels per acre are obtained. As a nurse crop wheat is considered better than oats, since the straw is lighter and shades the clover less, and wheat is not likely to

lodge. Practically the entire crop, aside from that saved for seed, is sold to the local milling companies or shipped through the local dealers, the bulk of the production being consumed outside the county. The screenings and the wheat of poorer grades are usually fed to poultry.

Minor crops grown in the county include rye and barley. The greatest production rye, as far as is shown by the census reports, was in 1889, when the 876 acres seeded to this crop produced 14,544 bushels. The census of 1910 records 636 acres, with a production of 9,627 bushels. Barley and buckwheat also had their maximum production in 1889, the area in barley being 444 acres and the production 9,779 bushels. For 1909, only 16 acres are reported in barley. The 144 acres in buckwheat in 1889 produced 1,560 bushels, or about 11 bushels per acre. For 1909, the census reports only 2 acres buckwheat in the county.

The census of 1880 records a production of 80,432 bushels of flaxseed. By 1890 the production had declined to 109 bushels, and the 1910 census does not report any flax grown in the county. Of minor grains and seeds grown, there is a small production of dry peas and edible beans, in addition to green peas grown to some extent for the local canneries.

Of the hay and forage-crop production, which according to the 1910 census amounted to 41,037 tons from 28,617 acres, 22,244 tons were of timothy alone. Timothy yields average about 1.4 tons per acre. Of clover alone, 4,140 tons, from 3,161 acres, were produced, and from clover and timothy mixed, 10,111 tons, from 7,133 acres, the yield here also averaging about 1.4 tons per acre. Millet or Hungarian-grass production declined from 335 tons in 1899 to 251 tons in 1909, although the average yield per acre remained about the same, 1.7 tons.

The census makes no mention of alfalfa previously to 1910, although it was grown many years prior. From the 160 acres devoted to this legume in 1909, 499 tons, or on an average, 3.1 tons per acre, were obtained. The growing of this crop is being rapidly extended, particularly by those farmers who are daicying or who feed milk cows, and both the county agricultural agent and the State Agricultural Experiment Station are engaged in efforts to increase the acreage in alfalfa. On account of the porous subsoils the second bottom or high-terrace lands are especially well suited to alfalfa, but with proper preparation of the land it can be grown successfully on almost any soil in the county except Muck and Peat. Its efficacy as a nitrogen-storing

agent, as well as its value as a money crop, favors its culture, especially upon the lighter colored Miami soils which are low in humus. The land for alfalfa should be well drained, limed, thoroughly inoculated, and free from weeds.

Only a small amount of hay of any kind is shipped into the county, and no considerable quantity is disposed of in outside markets, except in the immediately surrounding country. The greater proportion of the crop is fed to stock upon the farms where it is produced, the hay sold being chiefly that produced on rental farms where cash rent is paid or a division of the crops is made. The total value of the hay and forage crops produced in the county in 1909 is $350,826.

The acreage in special crops is comparatively small, but in the vicinity of Marion and some of the smaller towns the growing of special crops, chiefly potatoes and tomatoes, forms an important interest. In 1909, 223,409 bushels of potatoes were harvested, the yield averaging about 110 bushels per acre. The bulk of the potato crop is consumed locally, but there is not sufficient production to supply the local demand, and hundreds of bushels of potatoes from Michigan and eastern districts are consumed in the county annually. The tomatoes are grown chiefly for the local canning factories. The net income from this crop ranges ordinarily from $50 to $100 an acre, but the profit is quite variable with the season, and tomatoes are sometimes grown at a loss.

The growing of sugar beets has been experimented with in the last few years by many farmers, particularly those having small holdings. The industry promises to increase in importance. The beets are grown under contract with a sugar-manufacturing company, which has a plant located at Decatur, in Adams County, 46 miles east of Marion. The company provides seed, implements, and labor, making a stated charge per acre for these essentials. The grower furnishes and prepares the ground and cultivates and aids in harvesting the crop. The cost of production varies but averages $20 to $25 or more an acre, not including the grower's labor and the value of use of the land. The contract price has averaged about $5 per ton, f. o. b., cars at the shipping point. The returns are said to net the growers from $25 to $40 or $50 an acre. In some cases the growers are unable to give the sugar-beet crop the required attention and yields are below the average, being not infrequently unprofitable.

Trucking and fruit growing are carried on in the vicinity of

the larger towns and largely meet the local requirements, since only a very small quantity of fruits and vegetables is shipped into the county, except from southern or subtropical regions. A home garden furnishes most of the farmers with fresh vegetables throughout the growing season, the surplus being frequently disposed of. The total value of vegetables, including special crops, produced in 1909 was $194,184. Fruit growing is restricted almost entirely to small orchards of apple trees, with some pear, cherry, peach, and plum trees, on practically every farm. There are only a few commercial orchards in the county, and these are not important. The census shows 10,967 apple trees in the county in 1890, the number increasing by 1900, to 82,601. The census of 1910 reports 65,380 apple trees, 22,094 cherry trees, 20,063 plum trees, 15,964 peach trees, and 15,049 pear trees. The production in 1909 of other fruits enumerated, includes 127,652 pounds of grapes from 8,156 vines, 19,950 quarts of strawberries from 24 acres, and 11,548 quarts of raspberries and loganberries. The total value of all fruits and nuts produced in 1909 is reported by the census as $65,285. The apple is not considered a commercially profitable crop, since the average farmer cannot devote the time required to spray, prune, and properly care for the orchards. The crop of 1915 was one of the largest in the history of the county. In some cases the apples were hand picked and prepared for the market, but for the most part, only those were hand picked which were intended for home storage, the balance being made up into cider, fed to stock, or allowed to rot on the ground. Hogs were usually turned into the orchards to eat the fallen fruit, but even with this makeshift, hundreds of bushels of apples went to waste.

The value of the production of live stock and live stock products for 1909, totaled $2,352,619, which is $66,637 more than the value of all the cereals produced, and is more than double the value of live-stock products for 1889. The total includes $1,683,609 in animals sold or slaughtered; $273,919 in dairy products, excluding those used in the home; $370,971 in poultry and eggs, and $24,120 in wool. Animals sold or slaughtered on farms included 85,284 hogs, 3,026 calves and 7,230 other cattle, 7,729 sheep and goats, and 1,661 horses and mules. The live-stock activities deal mainly with the raising and fattening of hogs, cattle raising being of minor importance in comparison. The fattening of cattle was carried on extensively prior to the increase in the price of feed stuffs, the cattle being imported from

the West and kept for 30 to 60 days, but in recent years feeding has become unprofitable and is gradually being displaced by sheep raising. State and local laws protecting sheep against the ravages of dogs and safeguarding the industry in other ways have done much to encourage sheep raising.

A large proportion of the live stock raised is marketed outside the county, going mainly to the larger packing plants in Chicago, Cincinnati, and Indianapolis, although animals are also disposed of to several local plants, the largest being located at Marion. Only a very small percentage of the meat retailed in the cities and towns is obtained directly from the farmers. On the other hand, a very large proportion of the beef consumed on the farms is obtained through the retail merchants, particularly during the summer and at harvest time. The pork products consumed on the farms are chiefly produced at home.

Animal diseases are continually menacing stock raising, but through the cooperation of the farmers with various Government and State institutions the losses have been greatly reduced. Cholera was quite prevalent in some parts of the county at the time of the soil survey; every effort was being made to isolate and control the disease. In 1915, 3,000 head of hogs were treated with vaccine or virus.

Poultry and eggs and dairy products not only produce a large part of the farm income but are also important subsistence commodities used on the farm. Very few farmers make a specialty of dairying or poultry raising, but practically all have production above that required for home needs, and this is usualy disposed of at the local markets or to collectors of dairy or poultry products who call regularly at the farms throughout the year. A few dairies located near the larger towns deliver milk and cream, at retail, mostly in units of bottled pints and quarts, the product being generally sterilized or pasturized.

The local creameries and ice-cream factories utilize the greater part of the cream and milk collected on the daily rounds among the farmers. In most cases the cream is separated on the farm, sold, the separated milk being fed to the younger stock. The practice is quite general among the farmers to buy butter in exchange for cream, in the interest, it is said, of economy as well as of reduction in farm work.

The principal adaptation of crops to certain soils is that of wheat to the lighter colored soils and of corn to the black soils. No attempt is made to confine these crops to any particular type

of soil. The yield of corn upon the lighter colored soils average about half that upon the black soils, but the grain is conceded to be better in quality and more putritive. Tomatoes are grown usually upon the dark soils, because of the heavier yields obtained.

Breaking of the land seldom, if ever, precedes the seeding of oats, as the crop is almost invariably drilled in on the stalk land of the preceding year's corn planting. Disking and harrowing constitute about the only preparation given the land. Breaking is sometimes done in advance of the sowing of wheat but for the most part wheat is drilled between the corn rows. With breaking of the land the stand is more certain, and the crop is less susceptible to injury by extremes of wet or drought. Often the desire to get the crops in early leads to plowing before the ground has attained the proper physical condition, or when it is too wet, and clods are formed which can not be reduced readily by subsequent cultivation. This undesirable condition is more often encountered on the so-called clay lands.

The harvesting of corn is done largely with labor saving devices, the most popular being the corn binder, Practically no corn is cut by hand. The harvesting of wheat and oats is done exclusively with self-binders of the most improved type. Grain is threshed under co-operative methods, a number of farmers combining their labor. A variety of harvesting machines are used to cut, rake, and load hay, and the unloading and storing of hay in the barn are also done with labor-saving machinery. Little hand labor is used in the handling of hay and the other farm crops

Rotation in some form is practiced by most farmers. The one usually followed includes corn, wheat or oats, and clover, the purpose being to produce as much corn as possible without depleting the productiveness of the soil. The growing of cowpeas, soy beans, and alfalfa does much to maintain the humus supply, and the phosphoric-acid content is maintained by the use of artificial fertilizers, which are usually applied to the land at the time of the sowing of wheat. The phosphatic fertilizers are more often applied to the lighter colored soils and usually contain 6 to 8 or 10 per cent phosphoric-acid. Applications range from 150 to 200 pounds per acre. It is generally conceded that the use of these fertilizers improves both the yield and quality of wheat. Fertilizers high in potash, or muriate of potash at the rate of 100 to 150 pounds per acre, are sometimes applied to corn on the "black lands," particularly where the soil is high in organic matter or "chaffy." The application of lime in the

form of ground limestone at the rate of 2 to 4 tons per acre has been especially beneficial to the "clay land" for the correction of acidity of the soil. Commercial fertilizer, if depended upon alone for increasing crop yields, will ultimately injure, rather than improve the soil, but if used judiciously in connection with the growing of clover and other legumes, to enrich the soil in humus, they in general, increase the productiveness of the land. In 1909, a total of $12,580, or an average of $40.98 for each of the 307 farms reporting outlay, was expended for fertilizers in Grant County.

The total number of farms in the county in 1909 was 2,886 of an average size of 85.5 acres each. The value of all property on each farm averaged $10,629, of which 74.3 per cent represents land, 14 per cent buildings, 2.2 per cent implements, and 9.5 per cent domestic animals. The more improved farms exceed this valuation many times. The farm houses in Grant County are commodious and sometimes elaborate. The barns and other outbuildings afford ample rooms and convenience for handling the crops and live stock. The farms in the oil-bearing section, or the eastern and southeastern parts, of the county were neglected during the more prosperous years of the oil boom, when returns from leasing the lands for oil were far in excess of the profits obtained from farming. These farms are gradually being brought up to a higher standard of improvement.

Wages of farm hands vary with the character of the work and length of service. Harvest hands are paid $1.50 to $2 or more a day. The average wages by the month range from $25 to $30, in addition to board or a house, the keep of a horse and cow, and a garden patch. The labor is generally efficient and laborers are expected to handle all kinds of farm machinery. A large percentage of the farm work is done by the owner and his family. The total expenditure for labor in Grant County in 1909 was $264,670, an average outlay of $176.92 for each of the 1,496 farms reporting.

The census of 1910 shows 64.4 per cent of the farms of the county to be operated by owners, practically all the remainder being operated by tenants. The average rental for improved farms is $6 or $8 an acre. In many cases two-fifths or one-half of the grain goes to the owner, with a cash consideration for the use of pasture and hay lands. Usually, however, when a farm is operated on a share basis the net proceeds are divided equally between tenant and owners.

The price of land varies with its location and state of improvements. The average value in 1910, as given by the census was $92.32 an acre, but it is doubtful if any improved land can be bought for that price at the present time. Land values vary from $125 to $250 an acre, the average improved farm bringing from $150 to $175 an acre. Grant County is in a highly developed condition and not many of the farms are offered for sale.

Soils.

The upland soils of Grant County are derived directly from glacial till, while the alluvial or bottom lands include reworked, stream-deposited material from the uplands. On account of their depth, the underlying rocks have added but little to the various soil materials, other than that which they contributed originally to the ice-ground mantle of glacial drift which covers the area to a depth ranging from about 10 to 200 feet. This heterogeneous mass, which consists chiefly of silt and clay interspersed with sand and gravel, was left as a surface mantle upon the recession of the ice sheet at the close of the late Wisconsin epoch. The material of the drift naturally varies with the character of the rocks over which the glacier passes; these include granite, gneiss, limestone, sandstone, and shale. Niagara limestone of the Upper Silurian age underlies the glacial drift throughout the county, and exposures occur along the banks of the Mississinewa River and in the stream bed, particularly north of Marion. Well borings indicate its existence in other sections of the county. At various times, limestone quarries have been opened along the river, particularly in the vicinity of Marion, though only a few are now in operation.

Through the various agencies of weathering the glacial drift or till has been reduced to its present condition. In Grant County, to an average depth of 18 to 20 inches, the till is a rather uniform silt loam or silty clay loam, passing into a silty to sandy clay substratum. Below a depth of 3 feet the material is usually more friable, being an intermixture of silt, clay, sand, gravel, and angular stone fragments, more or less clacareous, as shown by effervescence in hydrochloric acid. Where the drainage is well established the surface material is generally light colored; otherwise it ranges from dark brown to black. In addition to weathering, the processes of chemical action, oxidation, and leaching are factors in the development of the various upland soils. These

are generally classed locally as "clay lands" (embraced in the Miami and Crosby series) and the "black lands" (included with the Clyde series), the former being the lighter colored, better drained soils, generally deficient in organic matter, and the latter comprising flat, low-lying, poorly drained soils with high organic-matter content.

The terrace soils, classed in the Fox series, include some of the best drained and most highly oxidized types in the county, excepting perhaps the Bellefontaine soil of the uplands, the latter being very similar to the Fox in character of material and color, but somewhat more irregular in surface relief.

The first-bottom soils, which are classed in the Genesee series are formed largely of wash from the uplands and necessarily, have some characteristics in common with the upland soils. They are predominantly rather fine textured. The texture of the material, however, is variable over short distances, particularly along the Mississinewa River, and the general uniformity of the upland soils forms a marked contrast to the lack of uniformity in texture in the case of the reworked, stream-deposited material of the overflow lands.

The soils of Grant County are grouped under six series, the Clyde, Miami, Crosby, Bellefontaine, Fox, and Genesee. Under these series nine types are mapped, not including Muck and Peat.

The surface soils of the Miami series are light to medium brown, or grayish, in color and are underlain by brownish-yellow or dull yellowish-brown, heavier textured subsoils. The Miami soils in the main are derived through weathering from glacial till of a general calcareous nature, and usually the subsoil below a depth of 18 or 30 inches is distinctly calcareous. The surface drainage is usually good, but owing to the low content of vegetable matter the soil material tends to run together and become compact if plowed when wet, this property being especially characteristic of the silt loam and silty clay loam, the only two members of the series mapped in Grant County. It is from this tendency of the soil to become compact that the term "clay land" is applied to the Miami types. The topography of these soils is comparatively level to undulating, but in places somewhat hilly.

The surface soils of the Crosby series are light gray or light brownish-gray in color, rather compact in structure, and of an acid character. Below the surface soil is a subsurface layer, similar in character, but somewhat heavier in texture, and of a light ashen gray color. This stratum is specked and streaked

with brown, and black iron stains, or is gray mottled with yellowish brown, and the material is decidedly acid, as shown by repeated tests with litmus paper. Below 12 to 16 inches, a dull yellowish-brown, compact, tough subsoil, consisting usually of heavy silty clay, is encountered. In the lower depths, generally at 2 to 3 feet, the subsoil is rather friable and more or less calcareous. The Crosby series is developed in level to gently undulating country, where both surface run-off and underground drainage are deficient. The Crosby series is derived from the same calcareous till that in the better drained situations usually give rise to the Miami series and under poorly drained or stagnant-water conditions develops the Clyde soils. Of the Crosby series, two types, the silt loam (mapped as Miami silt loam, flat phase, in the soil surveys of Delaware and Tipton Counties) and the silty clay loam, are mapped in Grant County. The term "clay lands" is applied locally to the Crosby soils as well as to the Miami, the material showing an even greater to become compact when wet, or break up into large clods if plowed in this condition, than is true of the Miami soils.

The soils of the Bellefontaine series are brown at the surface, with yellowish-brown to reddish-brown subsoils. The substratum below 3 or 4 feet is generally composed of alternate layers of sand and gravel, or of an intermixture of these. The topography is undulating to slightly rolling, and the drainage, both surface and subsurface, is good. Only one type of this seruesk, the Bellefontaine loam, is mapped in Grant County.

The surface soils of the Clyde series are dark gray to black in color, underlain by gray or drab subsoils, which are mottled with yellowish or rusty-brown streaks. The soils are developed in former lake beds and ponds, or low, poorly drained areas within glacial regions, through the accumulation of organic matter and the influence of poor drainage acting either upon the original glacial till of the basin or upon accumulations of water-laid material deposited over the floor of the basin. The surface is always level or depressed, the Clydes soils naturally having poor drainage, but where they are reclaimed, they are highly productive and include some of the best farm lands in the Middle West. Only one member of the Clyde series is mapped in Grant County, the silty clay loam, locally classed with the "black lands."

The Fox series, like the Bellefontaine, has brown surface soils and yellowish-brown to slightly reddish-brown subsoils. Below 30 to 36 inches, the substratum is loose and friable, usually con-

sisting of interbedded sands and gravel. The Fox soils have typically a level topography, being drained here and there, through potholes or by valleys eroded since the deposition of the materials as outwash plains or as terraces along streams within the glacial area or flowing out of it. The soil material consists largely or wholly of glacially derived material. Only one member of the series, the Fox loam, is mapped in this county.

The Genesee series includes dark-brown to grayish-brown alluvial soils occurring as first-bottom lands along the Mississinewa River and its tributaries. The soils of this series are subject to annual or at least frequent overflows. For the most part, however, the overflows accrue between the harvesting and planting seasons. Of the Genesee series the loam and silt loam types are mapped in Grant County.

The miscellaneous classification of Muck and Peat includes areas, of small extent and widely scattered over the county, where the material consists wholly or largely of organic plant remains in varying stages of decomposition.

The following table gives the name, acreage, and proportional extent of each type mapped:

AREAS OF DIFFERENT SOILS

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clyde silty clay loam	89,472	34.0	Fox loam	3,648	1.4
Crosby silt loam	53,568	20.3	Genesee loam	3,008	1.1
Miami silty clay loam	48,832	18.5	Bellefontaine loam	704	.3
Miami silt loam	38,336	14.5	Muck and Peat	640	.2
Crosby silty clay loam	20,608	7.8			
Genesee silt loam	4,864	1.9	Total	263,680	

Miami Silt Loam.

The surface soil of the Miami silt loam to a depth of 6 to 8 inches is a light-brown to brownish-gray silt loam, passing rather abruptly into a yellow to brownish-yellow friable silt loam, which extends to a depth of 8 to 12 inches and is in turn, underlain by a brown silty clay loam, mottled with drab. This grades into a darker brown silty clay. Below 20 to 24 inches, the typical dark-brown silty to sandy bowlder clay is encountered. This although,

stiff and heavy, readily breaks up under pressure, owing to an appreciable content of coarse sand and fine gravel. The coarser material increases with depth to about 30 to 36 inches, where a more heterogeneous admixture of clay, sand, gravel, and rock fragments of a gray to drab color, is encountered. The rock fragments are generally calcareous and effervesce readily when tested with hydrochloric acid. In the vicinity of stream courses, pockets of stratified sand and gravel occur, which are commercially developed as gravel pits.

The type is, in general, quite uniform, except where erosion has been sufficiently active to expose the coarser subsurface material at the surface, in which situations small rock fragments may occur in patches along with the bowlder-clay exposures, as is the case at the heads of certain gullies and along some of the steeper stream slopes.

The Miami silt loam is most typically and extensively developed in the vicinity of the Mississinewa River, particularly in the northern and northwestern parts of the county. It also occurs extensively along the general course of Pipe Creek. The type occurs in every township in the county except Van Buren, and covers a large proportion of Pleasant, Richland, Mill, Jefferson, Center, and Fairmount Townships.

The topography of the Miami silt loam varies from almost level to slightly undulating to rolling or hilly, the greatest relief being developed along the river bluffs and the larger creeks. The typical Miami silt loam is undulating to rolling, but where flat areas occur near the deeply cut stream channels the subsurface drainage is frequently sufficient to permit the necessary oxidation so that the typical Miami is developed, distinguishing the type from the Crosby silt loam, which occurs in similar situations but where subsurface drainage is deficient.

The Miami silt loam includes some of the best drained upland in the county and drainage is adequate for all crops. The steeper slopes along the streams occasionally need protection from erosion by terracing, but for the most part the type is not excessively drained.

Practically all the Miami silt loam is under cultivation, the exceptions being occasional patches of timber or woodlots which are preserved on most farms for shaded pasture and as a source of wood for domestic use. These wooded areas frequently include land of the rougher topography.

Wheat, oats, and hay are the principal crops grown on the

Miami silt loam. The type embraces some of the most productive wheat lands in the county, although the present yields are considerably lower than those which were obtained from the early clearnings. Corn is not so generally grown as wheat and oats, as it gives lower yields than on the darker colored soils, although the lower yield is said to be compensated for in part by better quality,, or feeding value. The use of the type for corn has increased in the last few years, since corn has become the most profitable crop in the farming system of the county.

The Miami silt loam is adapted to a wider range of agricultural use, and when properly handled the yields over an extended period compare favorably with those of any other type in the county, since this type is not so readily affected by extremes of wet and drought. As the Miami silt loam is well drained, crops mature earlier and more fully than on the more poorly drained soils, and a better tilth is possible.

The ordinary yield of wheat is from 20 to 25 bushels per acre,[1] although where commercial fertilizer is used yields are generally higher. The wheat grown is of good quality. Oats produce from 35 to 50 bushels per acre. Oats are not so likely to lodge on this type as upon the darker soils and the quality of the oats is better. Timothy and clover mixed produce from 1 to 2 tons of hay per acre, the average yield being about $1\frac{1}{3}$ tons. Corn yields on the average about 37 bushels per acre, although a return of 50 bushels per acre is not uncommon in favorable seasons, following the use of fertilizer upon wheat.

The Miami silt loam, next to the Bellefontaine loam, is the easiest of the upland soils to cultivate, and a loose, mellow seed bed can be obtained if care is taken to plow when the mosture content of the soil is favorable. If it is plowed when too wet large clods are formed which cannot be easily reduced by subsequent cultivation. This unfavorable tendency, however, is not so great as with the Miami silty clay loam, which has a higher content of clay and is more deficient in humus.

The resulting increased yields and better quality of the grain have led to a more extensive use of commercial fertilizers upon the wheat lands at the time of seeding. As upon the other, lighter colored soils, fertilizers high in phosphoric acid, containing from 8 to 10 per cent, are applied at the rate of 150 to 200 pounds

1. The statements made in this report as to yields of crops are based upon estimates obtained from farmers.

per acre. Some prejudices exist in regard to the employment of commercial fertilizers, but their use is increasing.

Few transfers of real estate have been made upon this type in recent years, but farms upon which it occurs are valued by the owners at $100 to $150 an acre. In the vicinity of the towns and villages, and where the farms are well improved, $200 an acre or more is asked.

The Miami silt loam is well adapted to alfalfa, soy beans, and other legumes, particularly where ground limestone is applied to the soil to correct any acid condition which may exist, and their culture could well be extended, Clover, though valuable as a soil-enriching crop, does not meet the full requirements for maintaining maximum crop yields. It has been shown by local tests that alfalfa turned under is more beneficial than clover for soil enrichment.

Miami Silty Clay Loam.

The surface soil of the Miami silty clay loam to an average depth of 7 to 8 inches is a brownish-gray, compact, heavy silt loam, which on drying, becomes light gray at the surface. The subsoil in turn to a depth of 10 or 12 inches is a friable silty clay loam, and grading into stiff, heavy, rather plastic silty clay, dull yellowish-brown in color, streaked with gray and rusty brown. Below 16 to 20 inches, the color is predominantly brown, and the material when treated with dilute hydrochloric acid effervesces rather freely, indicating calcareous influence. In the lower depths brown to black shale, and occasional limestone, fragments are encountered. Exposures of the underlying material below 4 to 5 feet are dull gray, similar in color to a ledge of the Niagara limestone if veiwed at a distance. The term "clay land" applied to all the lighter colored soils, is particularly applicable to this type, it probably carrying a higher content of clay than any other type in the county.

The Miami silty clay loam occurs chiefly in the north and east-central parts of the county, being confined almost exclusively to that portion east of the Mississinewa River. Its main development is in Washington, Center, Monroe, and Jefferson Townships, where it occurs as the predominant type. It occupies a large proportion of the rolling to hilly uplands and for the most part is more broken in topography than the Miami silt loam, although the slopes are precipitous only in the immediate vicinity of, or adjacent to, stream channels. The uneven character of the

surface usually assures ready drainage, and drainage for the most part is adequate for the general-farm crops to which the type is adapted. The tough nature of the subsoil retards somewhat the downward movement of any excess of moisture, so that the underground drainage is not always as good as the surface would suggest. In wet seasons the soil is sometimes saturated upon slopes, in situations where the Miami silt loam or Bellefontaine loam would be adequately drainage. The pale-yellowish and gray mottling of the upper layer of the subsurface material is a manifestation of this water-logged condition.

In point of extent the Miami silty clay loam ranks third (?) in the county. Practically all of the land is cleared and in use for general-farming purposes. Only a small proportion of the type is too rough for cultivation, and this is used for pasture. Some of the steeper slopes that were formerly cultivated have been given over to permanent bluegrass pasture. The type is used largely for wheat, oats, and hay, timothy being the main hay crop. Corn also is extensively grown, the yields, however, being considerably lower than upon the darker soils, particularly in wet seasons, as in 1915.

The agricultural use of the Miami silty clay loam is restricted almost entirely to general farming, although two of the largest dairy farms in the county are located upon this type in the vicinity of Marion.

The yields of wheat vary from 15 to 25 bushels per acre, the average being about 19 bushels. Oats average about 30 bushels to the acre, although larger yields are frequently obtained. The yields of corn vary from 25 to 40 bushels per acre, with an average yield of about 35 bushels. Timothy, the main hay crop, yields 1 to $1\frac{1}{2}$ tons of hay per acre.

Commercial fertilizers, as in the case of the other lighter colored soils, are applied to part of the wheat lands on the Miami silty clay loam, and their use could be extended with profit.

Prices of land in the eastern part of the county were unstable for several years following the discovery of petroleum, and farms were rated above their present value for agricultural purposes. During the period of the oil boom many of the owners abandoned their farms to live in Marion and the small towns. Now that the oil is largely exhausted land values have again become stable and $100 to $150 an acre is asked for farms located upon the Miami silty clay loam.

The extensive growing of timothy for hay on the Miami silty

clay loam has done much to deplete the soil of its humus content. Growing alfalfa more extensively to be plowed under would do much to increase the present impoverished content of organic matter.

Crosby Silt Loam.

(Mapped as Miami silt loam, flat phase, in Delaware and Tifton counties.)

The soil of the Crosby silt loam to an average depth of about 8 inches is a compact silt loam of a "leached" or light-gray color when dry, but darker or broonish-gray when moist. The subsurface material to 12 or 15 inches is somewhat heavier in texture, or a light silty clay loam, and typically is characterized by a mottling of pale-yellow or yellowish-brown and gray, and is decidedly acid. Below this to an average depth of 24 to 30 inches the subsoil is a yellowish-brown to rusty-brown, compact, tough silty clay, streaked somewhat with gray, and grading in the lower depths into a more friable silty to fine sandy clay, darker brown in color. This stratum below 3 feet becomes still less compact, and lighter in color and contains an appreciable amount of sand and fine gravel. The latter material is distinctly calcareous, as shown by its effervescence with hydrochloric acid, the reaction being naturally more vigorous with the coarser particles, which are more often fragments of limestone or chert.

The Crosby silt loam is confined almost exclusively to the western and southwestern parts of the county or that portion west of the Mississinewa River. It occurs for the most part in irregular, disconnected bodies a few acres to several hundred acres in extent, and is widely distributed. The largest development of the type being in Pleasant, Richland, Green and Liberty Townships. Where the Clyde silty clay loam is most extensively developed the areas of Crosby silt loam are small, and very irregular in outline, with a flat surface, and the type is but slighty elevated above the surrounding Clyde soil. It is in these situations that the typical Crosby silt loam is developed, which is naturally poorly drained. Where the bodies are more extensive the topography is not usually so flat. It is somewhat undulating, the soil is better drained, and the line of demarcation between the Miami silt loam and the Crosby silt loam is less distinct, so that the graduation from one type to the other frequently necessitates the drawing of an arbitrary line of separation. The distribution of the Crosby silt loam has a direct relation to the

natural drainage development, the surface and underground drainage of the type being generally deficient.

Owing to the extent and wide distribution of the Crosby silt loam it is one of the most important soils of the county, practically all of the type being under cultivation. It is used for growing all the grain crops, as well as clover and timothy, but the yields are considerably lower than upon the darker soils except in the case of wheat. This grain shows more adaptation to the lighter soils and so far as practicable the type is used for wheat. When first brought under cultivation the soil was richer in organic matter and much more productive than at present, as is shown by the marked reduction in the yields of wheat. The natural store of humus has been depleted by the continued cultivation without rotation of crops and to this depletion of organic content is due the light color or leached appearance of the soil and its tendency to clod when wet. Owing to the acid condition of the soil and the inadequate drainage, difficulty is sometimes encountered in getting a full stand of clover. The acid condition may be corrected, in part at least, by the application of finely ground limestone.

The use of the type is restricted largely to general farming, since a large proportion of the farm land in the sections of the county where the type occurs is made up of this soil. Some specialized crops and fruits are grown, but preference for growing these products is generally given to the lighter textured, better drained soils of the county.

The average yield of corn upon the Crosby silt loam is from one-third to one-half less than upon the black lands, being between 35 to 45 bushels per acre. The yields of wheat vary from 15 to 30 bushels per acre, with an average of about 10 bushels. The ordinary acreage yield of oats is about 30 to 35 bushels, although larger returns are frequently obtained. The hay produced upon this type, particularly in the case of timothy, is of good quality and yeilds ordinarily from 1 to 1½ tons to the acre.

A commercial fertilizer containing from 8 to 10 per cent of phosphoric acid and 1 to 1 per cent of nitrogen, with a somewhat higher percentage of potash, is sometimes applied to wheat at the rate of 100 to 150 pounds per acre, but for the most part only barnyard manure is used, the latter being generally turned under with the clover sod.

The farms upon which the Crosby silt loam occur are generally well improved and as the type is closely associated with the

Clyde silty clay loam the two are rated close together in value, the usual selling price being from $125 to $200 an acre. There are but few farms for sale.

Crosby Silty Clay Loam.

The surface soil of the Crosby silty clay loam to a depth ranging from 5 to 10 inches, and averaging about 8 inches, is a gray, heavy silt loam or light silty clay loam. The surface material when dry has a leached or grayish-white appearance, indicating deficiency in humus, slow movement of soil moisture, and low state of oxidation. The upper subsoil is a dull yellowish-brown mottled with gray, silty clay loam, passing into a heavy silty clay which becomes quite tough at a depth of 16 to 20 inches. Below 24 to 30 inches the structure becomes somewhat more friable and the material quite calcareous, in contrast to the overlying material, which shows little or no presence of lime when tested with dilute hydrochloric acid. On the other hand, a decided acid reaction is apparent when a moist sample of the surface or subsurface material is tested for acidity with litmus paper. This type, along with the other lighter colored soils, is locally called "clay land", the term being more applicable to this type than to the lighter textured soils.

The Crosby silty clay loam is more extensively and typically developed in Van Buren Townships in the northeastern part of the county. The same development extends into Monroe and Washington Townships, and there are smaller detached areas in Jefferson, Center, and Mill Townships. No areas of the type are mapped west of the Mississinewa River, it being confined almost exclusively to the broader level or flat to slightly undulating drainage divides which characterize the topography of the northeastern and eastern parts of the county and correspond to similar surface features of the Crosby silt loam as mapped in the southern, southwestern, and western parts of the county. As the topography is level or only slightly undulating the natural drainage is in few places adequate for the full development of the type, although the water table has been lowered and better drainage established through the drainage of the depressions, or flats and sloughs, occupied by the associated Clyde silty clay loam type. Frequently the Crosby soil is elevated only a few inches, or at most a few feet, above the surrounding more poorly drained Clyde soil.

Owing to its extent and wide distribution the Crosby silty clay loam is one of the important soils of the county. Practically all of the type is under cultivation. Although it is largely used for corn the soil is best adapted to the small grains—wheat or oats—which are used largely as nurse crops for clover, timothy being grown with the clover.

The type is restricted to general farming, to which use it is best adapted. The growing of specialized crops has received little or no attention.

The yields upon the Crosby silty clay loam are about the same as those on the other lighter colored soils, or, in the case of corn, from one-third to one-half lower than upon the "black lands." The ordinary yield of wheat is from 15 to 20 bushels per acre, although a return of 30 bushels is not uncommon. Oats yield from 30 to 35 bushels per acre, and the average yield of hay is 1 to 1½ tons.

Practically the only fertilizer used is barnyard manure, although commercial fertilizers are sometimes applied to wheat lands at the time of seeding. The fertilizer used in general is high in phosphoric acid, containing 4 to 10 per cent, and is applied at the rate of 100 to 150 pounds per acre.

The value of land of the Crosby silty clay loam cannot be definitely determined from transfers of real estate, since the farms include varying proportions of "black land" soils. The ordinary price of land in the section of the county where this type occurs predominantly is from $100 to $175 an acre.

The growing of alfalfa and soy beans upon this type is especially desirable as a means of stocking the soil with organic matter and nitrogen. The plowing of the soil when wet is detrimental, as a good tilth cannot be obtained under such conditions.

Bellefontaine Loam.

The surface soil of the Bellefontaine loam to a depth of 10 to 12 inches is a brown to slightly reddish-brown, sandy loam to loam or silty loam, underlain by a similar or brighter reddish-brown, compact silty clay loam or clay loam. This in turn, grades into a lighter or coarser textured friable clay loam which at 30 to 36 inches is loose or incoherent, generally giving way rather abruptly to beds of sand and gravel, brown to light brown in color, and quite calcareous.

The type is developed only in the vicinity of the Mississinewa

River, frequently including some of the higher bluffs. The most extensive and typical areas are found to the southeast of Marion, east and northeast of Matthews, and 2 miles southewst of Upland.

The Bellefontaine loam occupies high, rolling areas with good surface as well as subsurface drainage. The type is all under cultivation, used primarily for corn, wheat, and hay. The yields are about the same as on the Miami silt loam. Crops upon this soil are not so susceptible to injury from either excessive rainfall or drought, the yields being about the same year after year, where similar methods of cropping are followed.

The yields of corn ordinarily are from 45 to 50 bushels to the acre. Wheat and oats make an average acreage yield of about 20 and 30 bushels, respectively. The type is well adapted to small fruits, tomatoes, potatoes, and other garden vegetables. Apples grown upon this soil, not only yield well, but are of good quality.

Farms upon which this type occurs are valued at $125 to $175 an acre, according to the location and improvements. Very few real-estate transfers, however, have taken place in recent years.

For the commercial growing of apples or peaches there is no better soil in this section of the state than the Bellefontaine loam. It should be well adapted to alfalfa, although no alfalfa fields were observed upon the type during the soil survey field work. It is probable that some of the gravel beds underlying this type will in the future be utilized, precluding the use of part of the type for agriculture.

Clyde Silty Clay Loam.

The surface soil of the Clyde silty clay loam is a grayish-black to black heavy silt loam or silty clay loam, grading at an average depth of 8 inches into a bluish-black silty clay loam. This in turn quickly passes into a slate-blue to drab silty clay. Below this, from 12 to 15 to 30 inches, the subsoil is light to medium gray in color and somewhat more stiff and plastic than the overlying clay. It is also mottled with rusty-brown streaks or iron stains, the mottling being more pronounced below 20 to 24 inches. At 30 to 36 inches the heavier clay gradually gives way to a more friable silty to fine sandy clay, which in turn may be underlain whitish-low-grade marl or by sand and gravel, the latter occurring at various depths, but usually at 6 to 8 feet.

The sand, gravel, and marl are all highly stained with iron compounds. The gravel beds usually follow the course of the

natural drainage and are not infrequently exposed with the dredging of the outlets by which the type is drained. In those parts of the county not traversed by morainic ridges these gravel deposits form one of the chief sources of surfacing material for roads.

The type is fairly uniform throughout the county, but owing to differences in position, natural drainage, and local treatment, it has certain variations in color, texture, and depth of soil. The texture is naturally heaviest where the depth of the soil is least, as in the larger, shallower basins, while the color is darkest in the deeper basins, or in the situations where conditions have been most favorable for the accumulation of organic matter deposited largely by surface waters carrying in suspension decomposed vegetation from the uplands. Small mucklike areas are not infrequently developed in the lower situations. Cultivation tends to alter both the color and the texture of the soil. From the dark color of the soil the term "black land" is applied to the type in contrast to the associated lighter colored "clay lands."

The Clyde silty clay loam occupies irregularly outlined depressions in the uplands. It occurs as the most extensive and widely distributed soil in the county, but its main development is in the southern and southwestern parts, particularly in Franklin, Liberty, and Sims Townships, about half the total area of which is occupied by this type. It is also extensively developed in Fairmount and Green Townships. In the remaining townships of the county the rolling topography and unfavorable natural drainage features have largely prevented the development of this type.

The surface of the Clyde silty clay loam is flat or low lying, with little or no natural drainage. The type was originally in a semiswampy condition throughout the wet season, but in summer usually dry, except possibly for the small "buttonwood" ponds, which were permanently swampy. This type was generall too wet for cultivation under natural drainage conditions, a fact which accounted for its slow development. Its farming possibilities were not understood until in the early eighties, when adequate drainage outlets were constructed, giving the individual farmer an opportunity to drain his land. The building of good roads through the type permitted the farmers to handle their crops to better advantage. Artificial drainage was first effected by open ditches, but as these interfered with the cultivation of the type in large tracts they have largely been replaced in recent years by underground tile drains. The drainage outlets, which

have followed the general course of creeks and branches, have been made more effective by the deepening and straightening of the stream channels. The larger streams are left open and carry off more readily the flood waters and accumulated discharge from the tiled ditches. The drainage of the type in the western part of the county is largely through Pipe and Deer Creeks, while in the eastern part, Black and Walnut Creeks dispose of the drainage waters. The clearing away of the forest growth and subsequent tillage have contributed to the improved drainage of the type.

The Clyde silty clay loam is not only the most extensive but also one of the most productive types in the county, and since practically all of it is under cultivation, ranks first in agricultural importance in the county. The particular adaptation of this soil to corn has increased its value. The ordinary yield of corn, the most profitable grain crop grown in the county, is from 10 to 30 bushels more than that generally obtained from the lighter colored soils. Tomatoes in favorable seasons produce their largest yields upon this type, though their firmness and keeping quality may not be so good as in the case of tomatoes grown upon certain other soils. Similarly increased yields are obtained with such crops as oats, cowpeas, soy beans, clover, and sugar beets. The type, however, is not so well adapted to wheat. The larger yields of forage crops and grasses, and of corn for ensilage, insure better returns from dairying and stock feeding than in the case of "clay lands."

Crops grown upon the Clyde silty clay loam usually mature later than upon the lighter colored soils, chiefly because of the ranker growth of vegetation due to the higher content of nitrogen or organic matter in the soil. Lateness in maturity is particularly true of tomatoes, which never mature a full crop. Frequently, not more than half the fruit is ripened before the vines are nipped by frost. Wet seasons still farther retard the development of the fruit, so that much of it specks or rots in the field.

Aside from the first bottoms lands, the Clyde silty clay loam is generally recognized as the best corn soil in central Indiana, if not in the State, and its use, so far as practicable, is restricted to this crop—often to the detriment of the soil. The increasing demand for corn for stock feeding and other purposes has led to the extensive planting of this grain, not infrequently to the exclusion of other crops, so that there is not sufficient crop rotation to maintain the productiveness of the soil. The practice of the one-

crop system is naturally more general with the tenants than with the farmers who operate their own land. The tenant system is being extended as capitalists from the towns and cities invest in farm holdings, the "black lands" or "corn lands" being among the most attractive investments because of their suitability to the production of corn and hogs, the leading income products of the farms.

The yields of corn upon the Clyde silty clay loam has varied from 40 to 80 or more bushels per acre, with an average of about 55 bushels. The ordinary yields of wheat seldom exceed 18 to 20 bushels and this crop is more subject to heaving and is more likely to be injured by ice and standing water than upon the better drained "clay lands." The heads also do not fill as well, although a heavier straw is produced. Oats yield from 30 to 50 bushels per acre, and the straw is heavier than upon the lighter colored soils. In wet seasons, however, the crop lodges badly, and there is considerable loss unless the growth can be utilized for hay or pasture. Alfalfa can be successfully grown on this type if proper attention is given to draining and turning the soil. Although the quality of the hay may not be as good, heavier yields will apparently be obtained from this type than from the lighter colored soils. More careful curing of the crop, however, will be required.

The Clyde silty clay loam, if properly handled, is capable of being reduced to a fine, mellow tilth, but if deep plowing is done while the subsoil is more or less saturated, clods are formed which cannot always be broken down by subsequent cultivation. Late springs, with excess of rainfall, too often tempt the farmers to work this soil before it becomes dry enough to turn and pulverize properly, and in this way the physical condition of the soil is frequently impaired for even more than one season.

Where commercial fertilizer is applied to this type, it is generally in the form of muriate of potash and at the rate of 100 to 200 pounds to the acre. Its use, however, is more general upon the "mucky" phases of the type, locally called "chaffy land," where the corn tends to burn or turn yellow and the crop does not properly mature.

The rapid increase in land values in this and adjoining counties has been due largely to the wide distribution of the productive Clyde silty clay loam throughout this part of the State. The value of individual farms is not infrequently determined by the included area of this "black land", which is valued at $150 to

$200 or more an acre, according to the proximity of the land to town or city and the character of the farm improvements.

Fox Loam.

The surface soil of the Fox loam to a depth of 12 or 15 inches is a brown loam or light silty loam, underlaid by a somewhat lighter brown, heavy silty clay loam or clay loam which becomes more friable or sandy below 20 to 24 inches. At about 30 inches the change to lighter material becomes more rapid, a loose, friable, sandy to fine gravelly loam being encountered here. This in turn passes into stratified layers of sand and gravel below 3 to 4 feet. In color and character of material, the Fox loam is very similar to the Bellefontaine loam, the main differences being in their topography and respective positions upon the river terraces and the uplands.

The Fox loam is known locally as second-bottom land, although it occurs upon both the second and third terraces above the river. Before the type was cleared of its native forest growth it was commonly called "sugartree flats" and included some of the first land to be cleared, it being, a strong, well-drained soil. The type is confined almost exclusively to the terraces of the Mississinewa River and Jocinah and Walnut Creeks. It is most extensively and typically developed along Jocinah Creek and the Mississinewa River in Pleasant Township, although small areas are scattered along the entire course of the river in this county. The city of Marion is in part located upon this type.

The surface of the Fox loam is generally level, or slightly undulating if the terrace has been eroded, but it is never rolling. It has sufficient relief to insure ample surface drainage and the open, porous nature of the substratum admits of the ready downward movement of any excess of moisture.

The fox loam, though not as extensive as some of the lighter colored upland types, is more productive and is well adapted to a wide range of agriculture. It is especially well suited to the growing of alfalfa. If its adaptation to this legume is understood, however, it is not practiced, since no fields of alfalfa were observed upon this type during the course of the soil survey. Corn is the main crop, although wheat and oats are also grown extensively. Crops are not as likely to be injured by excessive rainfall or drought as upon the heavier upland soils, and full maturity of the crop is generally assured.

The use of the type is largely restricted to general farming, although it is equally well adapted to the growing of truck, including potatoes, tomatoes, peas, and beans, and to fruit growing.

Commercial fertilizers containing from 8 to 10 per cent phosphoric acid, 1 to 2 per cent nitrogen, and about the same percentage of potash are sometimes applied to wheat, but for the most part the productiveness is maintained by the usual crop rotation, with an occasional application of barnyard manure.

The crop yields are fairly uniform from year to year, the ordinary yields of corn being about 40 to 45 bushels per acre, of wheat 20 to 25 bushels, and of oats 30 to 40 bushels.

The Fox loam is more sandy and friable than the silt loams and silty clay loams of the uplands and is easier to cultivate; a good tilth is readily produced.

Land of this type, along with the first-bottom lands or adjacent uplands, is valued at $125 to $250 an acre, according to the improvments and the proximity to Marion. Within the city limits of Marion the prices are naturally much higher.

Genesee Loam.

The surface soil of the Genesee loam to a depth ranging from 10 to 15 inches, and averaging about 12 inches, is a medium to dark-brown fine sandy loam to loam or silty loam. The upper subsoil is very similar to the surface soil in texture, but is usually lighter brown in color. Below 18 to 20 inches the substratum is frequently made up of horizontal beds of clay and sand.

Since the Genesee loam is an alluvial soil, both the surface soil and subsoil are quite variable over short distances, owing to differences in the movement of depositing stream currents at various flood stages. In the immediate vicinity of the streams and across the sharper bends where the currents are swift, coarser particles have been deposited, the soil in many places consisting of a medium to fine sand. Along the larger bends or in settling basing where the waters are less turbulent the deposition of the finer sediments gives rise to the heavier or silty phases of the type, which are usually somewhat darker in color. It is from the intermixture of the sand and silt that the Genesee loam is derived.

The type includes all of the overflow bottoms of the Mississinewa River and part of the first-bottom lands along some of its tributaries. The bottom lands are generally flat or level, cut

across by numerous creeks and branches tributary to the main stream. The drainage is fair to good throughout the greater part of the year, and for the most part admits of cultivation. In the lowlying situations, ditches have been constructed to carry off the excess water.

The Genesee loam is not so extensively developed as most of the upland types, but its high yield determines its importance. It is used largely for grain crops, particularly corn. Where it occurs in the vicinity of Marion and some of the larger towns it is used to some extent for trucking, the largest truck farm on the type being located in the northwestern corner of section 19, Washington Township. That part of the type not cultivated is utilized for pasture.

The lighter, sandy phases of the type are more often selected for trucking. Melons, cucumbers, potatoes, and tomatoes are among the most profitable truck crops. Only those crops are grown which can be matured between the flood periods, but overflows seldom come at such a season of the year as to interfere with the use of the soil for trucking. Corn is quite a profitable crop, since some of the largest yields in the county are not infrequently obtained from the bottom lands. Yields of 60 to 70 bushels are usual. The yields vary considerably with the character of the season and the cultivation which the crop received, the latter being somewhat dependent upon the lateness of the spring floods.

Some commercial fertilizers are used upon the truck crops where it is desired to force them to an early maturity. The annual depositions of alluvium, however, is the main source of the productiveness of this soil, and in consequence the crop yields have shown a decline since the land was first cleared and drained, largely owing to the tendency to cultivate corn to the exclusion of other crops.

The farms are in no case so constituted as to include exclusively first-bottom land, so that accurate selling values for the type cannot be given, but in association with adjacent soils it sells at $100 to $200 an acre, according to the location and the proportion of the type under cultivation.

With proper farm methods it is possible to bring practically all of the type under cultivation. It is claimed that the clearing of the bottom lands and the adjacent slopes is responsible in large measure for the destructive effects of floods in recent years. Surveys of the bottom lands and a study of the effect of clearing them

of the native forest growth have been made by the State in recent years. Some of the larger cities also have sent out engineering corps to study the effect of straightening and deepening the channels of the river, and improvements of this nature will affect the future development of this soil.

Genesee Silt Loam.

The soil of the Genesee silt loam to an average depth of 8 to 10 inches is a brown to dark-brown, heavy silt loam or, in places, silty clay loam. This grades into a very dark brown to almost black silty clay loam and this in turn into a drab to slate-blue, stiff, plastic clay, mottled with shades of brown or iron stains. The color of the substratum becomes lighter with depth. The brown stains are due in part to the decay of roots, which have penetrated the subsoil to various depths. The dark color of the soil is due to the accumulation of organic matter from decayed vegetation, these bottom lands having been originally low and semi-swampy in many places.

Where this type merges into the Clyde silty clay loam the boundary drawn is frequently an arbitrary one, to the similarity of these two soils in color and the very gradual change in texture. Where the type occupies old, partially filled-in valleys, its origin is not unlike that of the Clyde silty clay loam where the latter type occupies elongated or ponded areas. Adjacent to the stream channels and in the narrow necks of the valleys the surface soil is usually lighter textured than is typical. Where the currents during periods of overflow are swifter and can carry the heavier materials in suspension the soil is similar to the Genesee loam, though the material is heavier in the lower depths, where deposit was made by more sluggish currents.

The Genesee silt loam is most extensively developed along Lugar, Walnut, Black, Deer, Pipe, and Back Creeks. The type occurs as first-bottom land bordering the streams. Other less extensive developments of the type are found along the smaller creeks and branches. It occurs in narrow strips, even in the larger valleys seldom exceeding one-fourth mile in width.

The low-lying position of the type necessitated the installation of artificial drainage, which has been largely effected through the deepening and straightening of the natural drainage outlets by dredging. In addition, tiled laterals have been properly placed to carry off the excess surface water, and the greater proportion of type is now under cultivation.

Corn is the chief crop grown, and some of the largest yields in the county are obtained on the Genesee silt loam. The average yields, however, is about the same as that obtained from the Clyde silty clay loam, approximately 55 bushels per acre, although returns of 70 to 80 bushels per acre are not infrequent. Oats are grown to some extent and produce heavy yields, but frequently the full crop cannot be harvested because of lodging. Owing to the low position of the Genesee silt loam, wheat is likely to be injured by overflows is seldom grown. The type is one of the best grass sown in the county, and hay yields 1½ to 2 tons per acre. On the better-drained areas heavy yields of tomatoes are produced.

Owing to the heavy yields of corn produced and the slow depreciation in productiveness of the soil, the tendency is to grow corn to the exclusion of all other crops. Rotation is practiced only to a very limited extent.

When the season is favorable, a good tilth can be obtained with this soil, but too often when the spring planting has been delayed by late overflows or other wet conditions the soil breaks up in large compact clods which cannot be broken down readily by subsequent cultivation. This haste to get in the crop frequently impairs the physical condition of the soil for even more than the one season.

No fertilizer is applied to this soil, the deposition of sediment being the only source of added fertility aside from the plowing under of oats and corn stubble and the native vegetation. In many cases the addition of potash would increase the corn yields.

Land of the Genesee silt loam is valued, in association with the adjacent uplands, at $100 to $200 an acre, according to the location and the condition of drainage, or the general possibilities of development.

Muck and Peat.

The type mapped as Muck and Peat represents mainly Muck, with included areas of Peat. The material consists of dark-brown to black accumulations of organic matter in different stages of decomposition, mixed with varying quantities of other transported soil material including silt, clay, and sand. The soil mass, however, is built up largely from the remains of cattails, rushes, mosses, sedges, grasses, and other water-loving plants which originally occupied and filled up the shallow lakes and ponds in which Muck and Peat now occurs. Muck and Peat are alike in origin,

but are distinguished from each other by the state of decomposition of the vegetable matter of which they are composed. The Muck is darker in color than the peat, and finer or smoother textured. The latter is more fibrous, consisting of a less decomposed mass of vegetable matter than the Muck, and is found where the organic material is deepest, generally near the center of the depressions. The depth of Muck and Peat varies from a few inches near the margin of the area to several feet in the deeper places. The organic material is generally underlain by a bluish-black, stiff, plastic clay, which grades below into a lighter-colored or grayish, mottled clay. Occasionally impure shell mark occurs embedded with the underlying material.

The bodies of Muck and Peat mapped are relatively small and widely distributed, although their occurrence is confined to the eastern half of the county. The largest and most typical development of the type is between Fairmount and Fowlerton. There are smaller areas skirting Lake Galatia; two miles southwest of Fowlerton; south and southeast of Gas City; 2 and 3 miles southeast of Upland, and 3½ miles southwest; and 3 and 4 miles northwest of Van Buren, and 3 miles southeast of that place.

The type occupies old filled-in valleys and shallow lakes and ponds which had no natural drainage outlets. Artificial tile drainage and subsequent cultivation have reclaimed most of the areas for cultivation or for use as pasture. These were formerly swamps throughout the greater part of the year. The native grasses which grew in the better-drained places were used by the early settlers for hay.

Muck and Peat at present is of little agricultural importance in the county, aside from its local value, owing to its limited acreage and lack of use for other purposes than general farming. No efforts have been made to develop the type for specialized crops, such as celery, cabbage, Irish potatoes, beets, turnips, cauliflower, and other vegetables, to which it is well adapted. The greater part of the areas brought under cultivation are used for corn, oats or timothy. Oats produce a rank growth but lodge badly. Corn sometimes "burns" or turns yellow without fully maturing, a tendency which can be largely corrected by liberal applications of barnyard manure and by the use of potash salts applied at the rate of 150 to 200 pounds per acre. Lime judiciously applied is also beneficial.

The Muck and Peat lands are never sold separately, but farms upon which they occur are held at $125 to $175 an acre.

SUMMARY.

Grant County is situated a little northeast of the geographical center of Indiana. It has an area of 418 square miles, or 267,520 acres.

The surface varies from a level to undulating till plain broken only along stream courses, particularly those of the Mississinewa River and its larger tributaries, where the valleys are generally deep and narrow.

The Mississinewa River is the chief drainage outlet of the county. Artificial drainage has been installed extensively in the more poorly drained sections of the county.

The population of the county is reported by the 1910 census as 51,436, of which 26,337 is rural. Marion, the county seat and largest town, is situated on the Mississinewa River near the center of the county. It has a population of 19,359 and is an agricultural and industrial center. Gas City, Fairmount, Jonesboro, Van Buren, and Upland are other important towns.

An excellent system of sectionized, gravelled public roads extends over the entire county. Four steam railroads and two electric interurban lines provide adequate transportation facilities. The county is highly developed.

The climate is not subject to frequent very marked extremes of heat or cold. The annual mean temperature is 50.9 degrees Farenheit. The mean temperature for the winter is 28 degrees Fahrenheit, and for the summer, 72.2 degrees Farenheit. The average annual rainfall is about 36 inches, and is well distributed throughout the year. Five months is usually the duration of the growing season.

The agriculture of Grant County is in a highly developed state. Corn, oats, wheat, and hay are the main crops. The 1910 census reports a production of 3,299,221 bushel of corn, 985,806 bushels of oats, and 285,447 bushels of wheat, the area in each being 67,391, 30,646, and 16,840 acres, respectively. The area in hay and forage was 28,617 acres, which produced 41,037 tons. Barley, buckwheat, and flax have practically been abandoned.

The greater part of the corn and hay production is fed to stock upon the farm or sold locally, while oats and wheat are more often sold in the open market. The special crops include potatoes, tomatoes, and sugar beets. Live stock, particularly hogs, is the main source of farm income, so that the operations generally center upon the animal industries.

The value of livestock and livestock products for 1909 totalled

$2,352,619, or $66,637 more than the value of all cereals produced. The cultivation and harvesting of crops are done largely with the most improved labor-saving machinery. Rotation in some form is practiced by most farmers, the one usually followed including corn, wheat or oats, and clover. Commercial fertilizers are sometimes applied to the wheat lands.

The total number of farms in the county in 1910 was 2,886, of an average size of 85.5 acres each.

The ordinary farm wages vary from $25 to $30 a month or $1.50 to $2 a day for harvest hands, the total expenditure for the county amounting to $264,670 in 1909.

The average rental for improved farms is $6 to $8 an acre, but only 34.4 per cent. of the farms are rented.

The average land value is given by the 1910 census as $92.32 an acre, but well-improved farms sell for $125 to $200 or more an acre.

Six series of soils are recognized and mapped in Grant County. The Miami, Crosby, Bellefontaine, and Clyde soils occur upon the uplands, the Fox upon the terraces, and the Genesee in the first, or overflow bottoms.

The upland soils are derived directly from glacial till of the late Wisconsin stage, while those of the bottom lands and terraces are derived from reworked and redeposited material which represents wash from the uplands.

Of the Miami series, two types are mapped, the silt loam and silty clay loam. These are best adapted to wheat and oats.

The Crosby series include the lighter-colored, poorer-drained upland soils of which two types are mapped, the silt loam, and silty clay loam. These soils are decidedly acid.

The Bellefontaine loam is somewhat rolling and well-drained. It is adapted to a wide range of crops, but is especially well suited to fruit.

The Clyde silty clay loam is extensively developed. It is especially well adapted to corn. Good yields of oats and hay are also obtained.

The Fox loam occupies the higher terraces. It is well drained and is adapted to a wide range of crops, being particularly well suited to alfalfa.

Of the Genesee series, two types are mapped, the loam and silt loam, the latter in places being really a silty clay loam. These soils are best suited to corn, although oats and hay produce good yields. They are subject to annual or more frequent overflow.

The type of muck and peat is limited in extent and unimportant.

Soil Survey of White County.

By T. M. Bushnell, U. S. Bureau of Soils, and
C. P. Erni, Indiana Department of Geology.

White County, situated in the northwestern part of Indiana, comprises an area of 324,480 acres, or about 507 square miles. The general outline is that of a rectangle, 24 miles north and south by 27 miles east and west, lacking, however, an area 5 by 6 miles in the northwest corner, and an area about 10 by 12 miles in the southeast corner. The county line is located along section lines, with the exception of several miles south of Monticello, where it follows the meanders of the Tippecanoe River.

The adjoining counties are Pulaski on the north, Cass on the east, Carroll on the south and east, Tippecanoe on the south, Benton on the west, and Jasper on the west and north.

The general topography of White County is that of a level to gently-undulating plain lying over 800 feet above sea level.

There are three main physiographic divisions, which are: (1) the till plain and low moraines identified by Leverett as of early Wisconsin age; (2) the old lake plain and associated ridges of the Kankakee basin; and (3) the bottoms of the Tippecanoe River and its tributaries.

The first main division occupies the southern half of the county, and is divided into timbered and prairie regions. The timbered belt or "clay land" is found adjacent to the Tippecanoe River, and extends 3 to 7 miles westward into the prairie region, as long tongues along the larger creeks. The area lying between the Pennsylvania Railroad and the Carroll County line is included in this region. Throughout the timbered belt are areas of black land which were the beds of old sloughs and marshes. The timber growth was never so heavy in White County as farther east in Indiana, but the original forests contained many large trees, such as white, red and black oaks, hickory, tulip, elm, sycamore, maples, walnuts and basswood. The topography of this region is comparatively uneven because of the several stream valleys which are cut through it and on account of a few low morainic ridges occurring in this locality.

The prairie region occupies the southwestern portion of the county. On the east the prairie dovetails with the timbered land along the Tippecanoe River, and extends north to the low wooded sand ridge which passes from Monticello through Smithson and West Point church. The prairie also includes the land within a radius of three or four miles of Wolcott, but in that locality the soils are somewhat lighter in texture than the main body of prairie land.

The prairie region is a gently undulating plain, which was originally devoid of all trees except for some large lone cottonwoods and a few isolated groves where timber had gained a foothold and was protected from prairie fires by surrounding bodies of marshy land. Several low morainic ridges traverse this region in an east-west direction, one of which passes just north of Badger Corner, and another along the northern line of Round Grove township, etc. From the tops of these ridges the very flat land between them often resembles an old lake basin. Much of the land was originally very marshy, and water covered it during rainy seasons, but it is now well drained by ditches and tile drains. The soils are deep, black and of a very uniform silty texture.

The northern half of White County is part of or related to the old lake plain or marshes of the Kankakee basin. It skirts around the prairie land about Wolcott and is separated from the silty or "clay" lands on the south by a sharp boundary which is marked by low broken sand ridges running through West Point church, Smithson, Monticello, Idaville, and Burnett's Creek. Often this boundary is a sudden and absolute change from deep yellow sand to heavy black lands, while elsewhere there are transitional zones of loam and fine sandy loam soils.

While the general topography of this lake region is quite flattish, every section is broken more or less by sandy ridges from 3 to 40 feet high. The ridges enclose the flats in such a way as to prevent natural surface drainage, so caused by the formation of extensive marshes and ponds where muck beds were often developed. The ridges were invariably timbered, as were some of the better-drained flats, but the wetter areas bore a heavy growth of marsh grasses, rushes, and flags.

Probably the original material of this region was laid down by ice in glacial times, and was subsequently reworked and assorted by stream and wave action in shallow waters of lakes formed from the melting ice. Then, before vegetation protected the soil, the land surface was more or less reworked by wind, and in some

places was blown into dunes of remarkably uniform-textured fine sand. In some of the larger ridges, as in southeastern Cass township, the core of the hills may be old moraines of boulder till, but such material is now entirely covered by the wind-blown sands. The sandy material extends down to bed rock in the northern portion of White County, but farther south it overlaps the early Wisconsin till plain, and in places is only a thin veneer over the heavy land.

The third physiographic division, or river bottoms of White County, embraces a relatively small area. Along the Tippecanoe River and some of the larger creeks there are narrow overflowed bottoms seldom more than 200 or 300 yards wide. They lie 3 to 10 feet above normal stream level, and from a few feet to over 100 feet below the general level of the plains. Often the bottoms are bordered by steep slopes or perpendicular bluffs, and the eroded belt of land seldom extends more than one-quarter of a mile back from the valley.

Within most of the larger bends of the Tippecanoe River below Wright's Ford and along the larger creeks there are second or non-overflowed bottoms, which lie from 10 to 40 feet above the streams. These are the remnants of old flood plains formed by the streams when they carried volumes of water from the melting glaciers and so formed the characteristic gravel substratum. These terraces are usually flat, although a number of them have decided slopes from their upper limits to the first bottom level. They are uneroded except where tributary streams cut through them.

The general level of White County is between 800 and 900 feet above sea level. The vicinity of Monon is probably the highest part of the county on the average, but Hickory Ridge about 3 miles north of Brookston is the most pronounced elevation. It rises about 50 feet above surrounding lands. Another moraine of relatively pronounced relief is found north of Chalmers.

Most of White County lies in the drainage basin of the Tippecanoe River, which crosses the north county line near Buffalo and flows in a general southerly direction to Monticello. It forms the east county line for about 5 miles south of Monticello, and from there flows only a short distance east of the county line. Bends of the river enter White County for a short distance at the Springboro bridge and at the southeastern corner of Prairie township.

Formerly a large part of the area had limted natural surface

drainage, and no network of small streams was developed. Their channels, which were ill-defined beyond 2 to 7 miles from the Tippecanoe, did not effectively drain even the adjacent land. Often ponds existed within a few feet of stream bluffs for lack of outlets. Now a complete system of dredged and scraper ditches and tile drains rapidy carry away the rainfall from almost all parts of the county. The Big Monon Creek and its branches head in Pulaski County and drain the land north and east of Monon into the Tippecanoe River. The Little Monon and its branches head around Wolcott and flow towards Monon. On account of the limestone bars in the original creek bottom, much of the water now flows through the dredged cutoff, passing about three miles south of the town, and emptying into the Tippecanoe at Wright's Ford. Honey Creek parallels in a general way the Little Monon, and empties about three miles north of Monticello. The northeastern part of the county is well drained by the Headlee, Patton, Burgett, Keans Creek and Pike Creek ditches, which flow in a westerly direction.

The county has an abundant supply of good drinking water free from salts, drawn from surface and driven wells and from springs.

The east and west line of sand ridges which bisects the county also divides the drainage. South of it Big, Spring, and Moots Creeks, together with several small streams, carry off the waters of the prairie region towards the east and southeast. A portion of Round Grove township is drained by the Vanatta ditch, which flows southward into Benton County and finds an outlet through the Fox River into the Wabash. Burnett's Creek also flows into the Wabash. The land around Lee and in the northwestern part of Princeton township also lies outside of the Tippecanoe basin, and the waters drain westward into Jasper County.

At Buffalo the Tippecanoe valley lies only 15 to 30 feet below the surrounding country; at Monticello it is 85 feet below the plain, and its valley reaches a depth of over 120 feet near the southern border of the county. The upper course is comparatively straight, with moderate currents and sandy bottoms. As it nears the border of the old lake plain the valley becomes deeper, the currents swifter, and the bottom more rocky, and ox-bows accompanied by high terraces appear. At Norway a small outcrop of shale occurs, and the "limestone riffles" below Monticello show where the stream has cut down through the glacial till to bed rock. The creek valley equals that of the river

in depth near their junction, but rises to the general land level within a few miles of their mouths.

The population of White County, as given in the Census of 1910, was 17,602, or 35 per square mile. It was classed as rural, as there are no large towns, and the interests and prosperity of the area are almost exclusively dependent upon agriculture.

The original settlers were drawn largely from the states lying east of Indiana, although a goodly number of pioneers came from Tennessee and Kentucky. They were of English, Scotch, Irish, Dutch, etc., stock. The county has received some people of foreign birth, though not in large numbers. Of recent years the country near Reynolds and Seafield has been colonized to some extent by farmers of German origin. Also there has been a large influx of Illinois farmers, who have been attracted by the rich black lands of the county.

Although there was a steady growth in population up to 1900, there was a decrease of over 1,500 in the following decade. A decrease in the number of farms in the county during the same period would indicate that some farmers were buying out their neighbors who then moved away.

Monticello is the county seat and largest town in White County, and had a population of 2,168 in 1910. It is centrally located on the Indianapolis branch of the Monon railroad, and on the Logansport and Effner branch of the Pennsylvania railroad. Good train service is afforded to Indianapolis (85 miles), Chicago (98 miles), and Logansport (22 miles). Monticello is the trading center for the surrounding country, and is a pretty residence town. It has several thriving factories supporting a few hundred persons, and a hydro-electric plant on the Tippecanoe River which supplies light and power to over twenty towns and villages.

Monon (population about 1,200) is a junction point for the several branches of the Monon railroad. Here are located rock quarries which supply large amounts of crushed limestone for the roads, and may become a source of agricultural lime. Brookston, Wolcott, Reynolds, Chalmers, Burnett's Creek, and Idaville are important small towns which are distributing and shipping points for the adjacent territory. Seafield, Lee, Smithson, and Guernsey also have grain elevators and shipping facilities. Besides these railroad towns, there are also settlements and country stores at Buffalo, Headlee, Sitka, Round Grove, Badger Grove, etc. Over 80 per cent. of the farms in White County are within 6 miles of from one to four shipping points.

Chicago is the principal market for both grain and live stock, although Indianapolis and the East get a part of the products shipped from the county. Feeding cattle and sheep are often bought in Kansas City, Omaha, and other western points.

White County has an almost complete network of well-improved roads, which is being extended every year. The main pikes are surfaced with gravel or crushed limestone, and are kept in good condition. There are some sandy roads in the northern half of the county, and some graded dirt roads in the southern portion, but practically all can be traversed at all seasons by farm vehicles or light motor cars.

CLIMATE.

The climate of White County is typical of north central Indiana. The year is almost equally divided by the average dates of the first killing frost in the fall and the last in the spring. The frosts and cold weather are usually limited to the time between September 30th and May 3rd, but have been known to occur several weeks earlier and later than these dates.

The Weather Bureau data recorded at Delphi, Indiana, may apply fairly well to White County, although Delphi is situated in the deep Wabash Valley, while White County occupies a higher level plain. The winter mean temperature is given as 26 degrees Fahrenheit, but there are often great and sudden changes of weather so the season becomes a series of cold waves and thaws with an average snowfall of 20 inches. The recorded maximum temperature of 70 degrees and a minimum of 26 degrees for January shows what extremes may occur. Other seasons exhibit equal variability. While the summer mean is 72 degrees, the temperature may go above 100 degrees or drop to 40 degrees.

The rainfall averages 37 inches per annum, and is well distributed throughout the year, being especially plentiful during the growing season. Each year brings unexpected conditions—perhaps rains or droughts of several weeks' duration—but the farmer can count on good average conditions during a term of years.

The climate is an important factor in determining the type of agriculture, and in influencing the yields. Since snow does not stay on the ground all winter, the growing of winter wheat and red clover is discouraged on lands where the alternate freezing and thawing might damage these crops. Before so many ditches were dug and lines of tile laid, spring rains sometimes delayed

corn planting until June, and the work in some fields is still retarded in this way. This fact, together with the possibility of damage from August droughts or early frosts, has probably discouraged the greatly increased use of silos for storing the corn crop. In spite of these possible drawbacks, the warm summer nights and abundant rainfall help make this a great corn country. The climate is also very favorable to the oat crop.

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT DELPHI, IND.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1907).	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	29.7	64	—12	2.49	4.88	5.53	4.2
January	25.1	70	—26	2.64	2.64	7.00	8.8
February	25.5	67	—24	2.34	0.90	0.32	7.4
Winter	26.8	70	—26	7.47	8.42	12.85	20.4
March	37.5	85	— 3	3.18	1.06	3.93	5.2
April	49.9	93	13	3.17	1.97	1.91	0.5
May	60.9	97	25	4.60	1.06	2.87	0
Spring	49.4	97	—3	10.95	4.09	8.71	5.7
June	70.7	99	37	4.40	1.42	5.50	0
July	74.4	104	41	3.74	2.68	6.43	0
August	71.7	100	37	3.03	2.69	3.86	0
Summer	72.3	104	37	11.17	6.79	15.79	0
September	65.0	100	25	2.91	2.81	3.94	0
October	51.9	91	18	2.09	0.76	1.31	T.
November	39.0	77	0	3.23	4.30	2.31	1.9
Fall	52.0	100	0	8.23	7.87	7.56	1.9
Year	50.1	104	—26	37.82	27.17	44.91	28.0

AGRICULTURE.

The soils of White County were first put to agricultural use by white men about 1820. The first land entered in this area is said to be at the Wolverton farm, 2 miles east of Chalmers. This and other early settlements were made in or near the timber land, as the trees were necessary for house building, firewood, etc., and the forests furnished the game which constituted a large share of the pioneers' food supply. Also the cleared timber land was easier to cultivate with the early tillage implements than was the tough prairie sod. The drainage conditions were also better.

Trees were girded to form deadenings, or else felled in windrows to make room for little fields of Indian corn, which was the main crop. "Log rollings" were great social events at which the whole neighborhood helped some settler roll logs from his fields for burning. In this way much fine walnut, oak, hickory, elm, etc., timber was destroyed.

The pioneer usually raised a little flax for cloth making, but abandoned this crop as soon as he was able to protect a flock of sheep from the beasts of prey, and then used wool instead of linen. Wheat began to be grown generally as soon as grist mills were provided to grind the wheat to flour.

Under that system the timbered portion of the county was gradually settled, and the main crops are still corn and wheat, although the latter has been replaced by oats to some extent.

The better-drained prairie land intermingled with the timbered ridges was first farmed in the 30's, but the "Grand Prairie," which extends unbroken westward into Illinois was left unsettled until the 50's. Then only the boldest pioneers dared venture far from the shelter of the timber to brave the prairie fires or cold winter gales. At that time much of the prairie was quite marshy during the rainy seasons, and a solid sheet of water often covered the land west of Chalmers for several miles. The slight elevations in the prairie were first broken and planted to corn. The crops were likely to be drowned out in the flatter fields.

Thousands of cattle were grazed on the prairie, but not in large herds. Each farmer owned from 300 to 800 head, which were herded on the unfenced ranges.

At that time even the poor sandy timbered land near West Point was valued at $20 per acre, while the broad fertile prairie could be bought for $8 per acre.

Although fencing and farming had been gradually increasing

on the prairie, the big crops and good prices of 1874 were largely responsible for the building of miles of three-board fence and the breaking of much virgin sod. Other changes came fast. In the same period the introduction of barbed wire made fencing an easier task. The land was being drained by dug and scraper ditches so that crops were surer. With the advent of the self-binder, oats became an important crop on the prairie, second only to corn, and as a natural result the cattle industry passed away.

Dredged ditching began about 25 years ago, and several of the main outlets have been deepened three times. The system of laterals is well developed, and of late years many miles of 24-inch and 30-inch tile have been laid in the open ditches and covered over so no land is wasted and farming operations are not hindered. In some sections the drainage outlets have cost over $20 per acre, and an equal amount has been expended for 4-inch, 6-inch, and 8-inch tile, which are laid in strings 50 to 100 feet apart. In this way much marshy land has been reclaimed and good crops are insured every year.

About 1895 an influx of Illinoian farmers into White County began, and a few are still coming each year. As a rule they use good farming methods, and are well-to-do. They created a demand for the black prairie lands, so that land values have risen to $200 or more per acre.

At the present time livestock feeding and all grain-growing types of farming are practiced, but in either case the growing of corn is the dominant industry on most farms. This crop has always led all others in acreage planted, and since 1900 has occupied about 100,000 acres each year, or nearly one-third of the total area of the county. The variations in acreage and in yields from season to season are wide. The Census of 1910 reports that 93,653 acres yielded 3,418,196 bushels, or about 36 bushels per acre. The corn crop is utilized in many ways. It is an important source of cash when sold direct to the elevators. It is fed the work animals, and to hogs, cattle and sheep, and the fodder is a most important roughage for horses and cattle. Corn silage is extensively fed to dairy cows and to beef cattle. Yellow varieties are planted almost to the exclusion of white kinds.

Since the introduction of self-binders and improved drills, oats has become a crop second only to corn in total acreage and yields. Only 13,628 acres were sown in 1879, but this was gradually increased to 57,532 acres in 1909. The average yields per

acre range from 28 to 37 bushels. This grain is partly fed on the farms to work stock, and the surplus is sold for cash. The straw is used for bedding or sold in towns. The wasteful practice of burning straw and stubble is seldom observed.

More wheat (16,052 acres) than oats were sown in 1879, but both the acreage and average yields have declined since that time. Many farmers believe that wheat is seldom a profitable crop, but others obtain returns which encourage them to sow this cereal every year. Wheat is strictly a cash crop. In 1909, 10,385 acres sown yielded 17 bushels per acre, which is better than the average.

Rye is of minor importance, though the acreage has been gradually increased. In 1909 2,775 acres sown returned about 11 bushels per acre. This crop is usually sown in small fields where special soil conditions prevail.

Buckwheat was sown on 744 acres in White County in 1909, and yielded about 11 bushels of grain per acre. When fields cannot be prepared in time to plant corn, they are often sown to buckwheat rather than to let the land lie idle.

No other cereals than those herein mentioned are grown in White County in noticeable amounts.

Hay has always been an important crop in this area. The Census of 1890 reported an acreage of 36,500, yielding about 1.18 tons of hay per acre. Probably much of this was wild prairie or marsh hay. In 1909 about 25,000 acres were devoted to hay and coarse forage, all except 2,437 acres being in tame crops. Timothy exceeds all other hays with an acreage of 15,429 and average yields of 1.16 tons per acre. Most of it is consumed by horses on the farms or in the local towns. An average yield of 1.18 tons per acre was obtained when timothy and clover were sown together on 3,823 acres in 1909. Clover was sown alone on only 791 acres in 1909, with average returns. Red clover is the variety most grown, and it often yields a seed crop as well as the hay. Big English and Alsick clovers are occasionally grown. Millet and grains cut green are unimportant hay crops. In 1909 45 acres in alfalfa yielded over 2 tons per acre. The acreage of this valuable hay has increased somewhat recently, but is far from being a general crop There is a considerable acreage of permanent blue grass pasture besides marshes and woods which are used chiefly for hay and pasture.

Within the last few years some cowpeas and soybeans have been grown, principally on the sandy soils. The value of these

crops for hay, grain and soil improvement is well known by the farmers with similar sandy soils in northern Indiana, and they will doubtless become more widely used in White County.

All farmers and many townspeople raise sufficient vegetables for home use, but none for shipping. Irish potatoes are grown in quantities about sufficient for the home markets. In 1909 705 acres yielded 90 bushels each.

Apples and peaches, also a few pears and cherries, are grown on a majority of the farms, but both the trees and fruit receive little attention. One commercial orchard near Monticello seemed likely to become a profitable investment.

Grapes, berries of different kinds, melons, etc. are grown in quantities for local use, but much early truck is shipped in from the south.

While 54.6 per cent. of the total value of White County products in 1909 was derived from cereals, about 35.7 per cent., or $1,666,640, was the revenue from livestock and products. Animals sold and slaughtered brought $1,255,709. About 30 per cent. of this amount was due to 37,318 hogs, while 65 per cent. is the value of about 2,500 calves and 11,000 other cattle. The remaining 5 per cent. was derived from 1,395 horses and 6,277 sheep.

Over 6 per cent. of the farm income is "poultry and egg money," while about 2.6 per cent. comes from the cream, milk and butter sold from the farms.

The crop adaptation of the soils of White County is well recognized and observed by the farmers, as is shown by the local distribution of crops in the area. Of course corn is grown on all types of soil, but it is well known that the deep black lands when not too wet or mucky usually give the best results. The reclaimed marshes produce good crops of corn. Oats is adapted to the same soils and conditions as corn, and does very well on the wetter lands. The prairie is almost ideal for grain farming, and will probably always be used for that purpose, although some livestock should be fed to help keep up the productiveness. Wheat is confined almost entirely to the light-colored soils. It also does well on the black sandy lands in the northern half of the county. Red clover gives better average yields of hay and seeds on the light "clay" lands, as it is somewhat subject to winter killing on black lands.

Rye is usually grown on poor, thin ground where other crops would not thrive. It is used to protect slopes which might wash,

and is the best crop for the sand dunes in the northern part of the county. It is often plowed under as a green manure, with good results. Its place on the sands may well be taken by cowpeas, which improve the soil by the addition of nitrogen and humus, and furnish a good leguminous hay. This change now seems to be imminent.

The adaptation of the sandy lands of the lake plain and stream bottoms to melons and other truck crops is well known, but lack of markets prevent the development of this industry.

The average farm in White County embodies very good equipment and farming methods. The farm homes are usually comfortable, and many have most of the conveniences of town. The telephone, Rural Free Delivery, and motor cars have removed the element of isolation from farm life.

The barns for horses and other stock are usually adequate. Granaries and cribs are provided for that portion of the crops consumed on the farms, but there is little storage room for grain which might be held for better market conditions.

Farm implements are of the most improved types, and constituted almost 27 per cent. of the farm values in 1910.

Part of the corn land is broken in the fall, and the remainder in the spring during April and May, according to the weather. Single and gagg (mould board) plows of the riding type are most used, though some disc plows are encountered. The land is broken to an average depth of 6 inches. Subsoiling implements are rarely used. The clods are disced and harrowed down to a good seed bed. Most of the crop is put in during May. The seed is planted by machine, with a fertilizer attachment, which applies from 100 to 200 pounds of commercial fertilizer per acre. It is drilled or put in check rows averaging $3\frac{1}{2}$ feet square. From 1 to 3 grains per hill are planted, according to the strength of the land. Often a roller or weeder is run over the field before the corn is up or when the first leaves appear. The first cultivation is usually deep and close to the row. Clod fenders are used to prevent covering the small corn. Subsequent cultivations are shallower and farther from the rows to avoid injury to the roots. The sweep type of cultivator is often used at this stage. The field is cultivated *across* each alternate time, and is usually kept very free from weeds unless wet weather interferes. After 3 to 5 cultivations the crop is laid by in July. The corn is harvested in a variety of ways. Probably the largest part is husked from the stalks in the field and hauled direct to elevators or to cribs,

which are slatted to allow drying Some farmers cut and shock the corn and husk it during the winter. The corn binder is used to aid in that operation, and also in gathering corn for silage. In some cases, especially when the corn is badly blown down, cattle and hogs are turned into the fields to harvest it. The practice of picking seed corn for next year at harvest time is not as general as it should be. More often the seed is picked from the cribs just before planting time.

The soil is seldom as well prepared for oats as for corn. The land is broken or only disced and harrowed if the weather is wet in the spring. It is seeded by drills at the rate of 1½ to 2 bushels per acre. The time of sowing is early in March. About the time corn is laid by and hay making is over, oats are put out with self-binders and shocked. Threshing begins as soon as the straw is dry, and most of the grain is hauled direct from the machine to market. Part of the crop may be saved for horse feed and seed. The straw is used for bedding, winter roughage, and roofs of winter shelters Much of it becomes incorporated with the manure and is returned to the fields, so is an important source of humus and potash.

Wheat may be drilled between corn rows in the fall or sown or stubble ground which has been broken and finely pulverized by discing and harrowing. It is harvested just before oats, and in the same manner.

The hay crops are sown on oat or wheat ground early in the spring, and occupy the land after the nurse crop is removed. Sometimes the fields may be pastured in the fall. The following season the hay crop is cut. Timothy is usually allowed to stand several years until it becomes thin. When timothy and clover are sown together the first crop is largely clover, but it dies out and leaves only timothy for succeeding crops. Red clover alone is cut for hay in June, and if the growth warrants it is cut again in the fall for seed.

The most common rotation on the prairie land is corn and oats, or corn, corn, oats. Sometimes they grow corn, oats, and clover. If a good stand of clover is not obtained, it is plowed up and put in corn, which then gives increased yields. On the "clay" lands corn, wheat, and clover are often a successful combination. The growth of legumes on such land is a vital need, but clover is not certain to "catch." Other rotations include timothy in place of clover.

White County farmers use all of their manure and feed live-

stock on land to build it up, but use relatively small amounts of commercial fertilizers. In 1910 23 per cent. of the farms reported an average expenditure of $48 for fertilizers. On the mucky or black "chaffy" lands of the lake plain region it is the general practice to use potash in some form on corn. It supplies a needed plant food, and kainit, especially is thought to prevent the attacks of certain insects.

White County farmers realize the advantage of feeding as much as possible of their corn to livestock. Better prices are obtained when corn is marketed as pork or beef. Nearly every farm raises enough hogs for home-killed meat and an excess of shipping. Corn is usually supplemented with a little bran, shorts, tankage, clover or blue grass pasture, etc.

Cattle feeding is even greater than the hog industry. Many calves are dropped by the general purpose cows found on all farms, but the bulk of the feeders are shipped in from the West or Chicago. These may weigh 900 or 1,000 pounds when put on feed, and are finished and shipped when weighing 1,200 to 1,400 pounds. They are often bought and sold on a narrow margin. The profit from feeding cattle lies principally in the gains made by hogs following them, and in the soil improvement. The principal feeds are corn, corn stover and silage supplemented by bran, shorts, etc. Winter feeding is most general, but some of the big feeders find it most profitable to feed in the summer so the cattle can be marketed at a season when the prices are highest.

A few sheep—mostly Shropshires—are raised in the county, but several thousand western feeders are imported each year. They are pastured on stubble, etc., and may be finished with a little grain. They make quick and profitable gains, and at the same time clean up the weeds in fence corners, orchards, etc.

There are several breeders of registered stock in the area. They breed good lines of Shorthorn and Hereford cattle and Duroc Jersey and Poland China hogs, etc. Most of the sires used in all stock breeding are pure bred.

Pure bred flocks of most important kinds of poultry are to be found in the county. Farm chickens are mixed, but are almost clear profit to the farmer, as most of their food is gleaned in the fields and around granaries. Hucksters gather poultry and eggs throughout the country and carry them to the towns. A packing plant at Monticello ships such products to the cities.

All the towns are supplied with milk from local dairies and nearby farms. Some cows are of the dairy breeds, but more are

of the general purpose type. Milk is collected by wagons for several creameries and ice cream factories in the county. A milk train on the Monon Railroad collects milk and cream along the line for the Chicago markets. A co-operative creamery was established at Reynolds a few years ago, but failed because of mismanagement.

Farm labor has become a large item of expense in White County. In the Census of 1910 48 per cent. of the farms reported that help was hired at an average cost of $236 per farm. Good laborers receive $30 to $35 and board per month, or about $1.00 per day for ordinary work. During harvest and hay making wages of $1.25 to $2.00 per day are paid. Many farmers exchange labor, especially at threshing time.

In 1880 the average size of farms in White County was 117 acres, 79 per cent. of which was improved land. The size has increased so that the average farm in 1910 contained 150.4 acres, of which 132 acres were improved.

While 65 per cent. of the farms were operated by owners in 1890, there has been a gradual growth of the tenant system, so that 44.3 per cent. of the farms are now operated by tenants and 2.2 per cent. by farm managers. There is a tendency for the land to pass into large holdings, and several individuals and companies now own 2,000 to 7,000 acres.

Land values gradually increased from about $20 an acre in 1880 to $38 in 1900. In the next decade there was a rapid rise to an average value of $77 per acre. Many farms in the prairie section are now valued above $200 per acre, and those of the light-colored "clay" lands at $125 to $175 per acre. Part of the increased value is due to the great improvement in ditches and roads, etc.

Soils.

The area of White County is approximately equally divided between an old glacial lake plain, known as the Kankakee basin, in the north, and a comparatively smooth hill plain in the south.

The underlying rocks of the area have contributed only indirectly to the formation of the soils, as they are usually deeply covered by glacial deposits. According to maps of the Indiana Department of Geology, the southwestern portion of the county is underlain by a dark-colored shale rock at depths ranging to 100 feet or more. Between Chalmers and Wolcott it may generally be found between 15 and 50 feet below the surface. A

sandstone formation occurs at some depth near Wolcott, and was formerly a source of sand for glass making. Only one outcrop of shale rock was observed in White County. It is found in the north bank of the Tippecanoe River, a few hundred yards above the mouth of Pike Creek and about 50 feet below the general level of the land. A line running northwest from that point is, in a general way, the limit of the shale deposits. Northeast of this line the land is underlain by the Niagara limestone. This formation outcrops in the bottom of the Tippecanoe River a short distance south of Monticello, and at a number of points along the Monon creeks. In the vicinity of Monon and Lee a pre-glacial limestone hill comes within 2 to 20 feet of the present land surface. Along the general line of junction of the limestone and shale deposits wells have been driven 140 feet deep without striking rock. This fact suggests the presence of a pre-glacial valley of considerable depth.

According to the glacial theory, this portion of the country was covered by a great glacier or ice sheet ages ago. It crept slowly down from the north, and at one time probably approached the Ohio River. It melted back and advanced several times. Each time the great mass of ice brought down soil and rock from the north, smoothed down the hills, and filled up the valleys in its path. The underlying rocks and those far to the north were ground, and the material was mixed and transported by the ice and the water formed by the melting ice. The old soils gave way to a heterogeneous mixture of material from limestone, shale, sandstone, and crystalline rocks ranging in texture from the finest clays to huge boulders weighing many tons. Where the material was laid down under the ice rather level land was left after the recession, but along the fronts of the glacier terminal moraines of comparatively rough topography were formed. In such places large boulders were frequently strewn thickly over the surface, but most of them have been removed from the fields in White County. The southern portion of the county has a very uniform silty covering from 1 to 3 feet deep, which, no doubt, is the result of the weathering of the glacial till.

When the ice sheet was melting the major streams carried larger volumes of water than at the present time. The great swift currents carried coarse sands, gravels, and stones, which were deposited in the bottom lands. Later the channels were eroded down to lower levels, leaving these gravel beds 5 to 40 feet above overflow. As with the till uplands, the material in

these terraces is of mixed origin, but a large proportion of the gravel is limestone.

Upon the last retreat of the great glacier, areas in northern Indiana were left in a marshy condition, and lakes occupied many of the depressions. This condition prevailed until about 1855, when great dredging operations were begun, which are rapidly making this land fit for agriculture. The marshes were typically developed in the Kankakee basin, but the same conditions continue to and terminate in White County, which is drained largely by the Tippecanoe River. The soils of this region are characterized by the very large percentage of fine sand particles which they contain, entire absence of stones and rather coarse material. In places the fine sand has been heaped into distinct dune forms, which have been protected from recent wind erosion by trees and other vegetation. Some of the sand ridges are supposed to be based on morainic cores. Recent alluvium in comparatively narrow strips occur along the Tippecanoe River and the other well-defined streams in the county. In permanent marshes the heavy growth of water-loving vegetation gives rise to muck beds. In a number of marshes there are local deposits of bog iron ore from a few inches to several feet below the surface. It is said that ore was dug and carried to the Wabash Canal in pioneer days, but the deposits are too small to be used or to influence the value of the land for agriculture very much.

In the southern and western sections of the county where the soil-forming material is unassorted glacial debris or till, four distinct series of soils are developed. Where this material existed under prairie conditions, it gives rise to the Carrington soils; when well drained and timbered, it gives the Miami soils, and in marshy areas it gives the heavier types of the Clyde series. The terminal moraines with more gravelly subsoils are better drained and oxidized, and are sources of the Bellefontaine soils.

The sand deposits spread over the northern part of the county give light types of the Clyde series in the flat, poorly-drained areas, and the Dunkirk series in the better drained, nearly level, and distinctly ridgy areas. All of the terraces are classed in the Fox series, and the first bottoms in the Genesee series. In all, eight series, including fifteen types besides the miscellaneous type, muck, were recognized and mapped.

The Miami series includes light grayish-brown soils resting upon heavier compact yellowish-brown subsoils, which usually are somwhat calcareous in the lower part of the 3-foot section.

They are gently undulating to rolling in topography, and have fair to good drainage. In White County the series is represented by the silt loam, loam, and fine sandy loam.

The soils in the Bellefontaine series are brown to slightly reddish-brown. The subsoils are yellowish-brown to reddish-brown, rather compact, and resting upon a porous mass of stone and gravel at shallow depths. They are smooth, rolling to very irregular morainic in topography, and usually well drained. The soil and subsoil are not calcareous, or only slightly so, but the underlying material is strongly calcareous, a large proportion of the material being from limestone. The loam and silt loam are represented in the county, these being confined to pronounced morainic ridges.

The Carrington series is characterized by dark-brown to almost black soils, with heavier-textured yellowish subsoils. They are nearly level to rolling in topography, and have fair to good natural drainage. They are derived from a moderately calcareous glacial till which has existed mainly under prairie conditions. The silt loam with a flat phase, which is intermediate in its properties between the Carrington and Clyde soils, is extensively developed in the western part of White County, and the loam in a shallow and flat phase development is of considerable importance in the northern part. The fine sandy loam is only limited in extent.

The Clyde series is characterized by dark brownish-gray to black surface soils, and gray or drab mottled subsoils. The different members of the series are flat in topography, usually occupying a depressed position with reference to the better-drained associated types, and they are naturally poorly drained. The heavier members of the series are derived from glacial till, the same as giving rise to the Miami and Carrington soils under better drainage conditions, while the lighter types through the lake plain area are from water-assorted material. The Clyde soils are extensive and widely distributed over the county, and have an important influence in the agriculture.

The Dunkirk series includes brownish-gray to brown or yellowish-brown to grayish and brown mottled subsoils of similar to somewhat heavier texture. The surface features are level to undulating and gently rolling, and the drainage is fair to rather excessive. The Dunkirk soils are derived from sedimentary deposits laid down on the floor and along the shores of glacial lakes, the soil-forming material being essentially noncalcareous. The

fine sand is the only member of the series occurring in White County.

The soils of the Fox series are grayish-brown to brown in color, and the subsoils are yellowish-brown to slightly reddish-brown resting upon stratified beds of gravel and sand, a large per cent. of which is limestone.

They occupy terraces and outwash plain areas level to undulating in topography and naturally well drained. The underlying gravel and sand beds carry a high percentage of limestone material.

The Genesee series consists of dark-brown to grayish-brown soils, with somewhat lighter-brown subsoils. The soil-forming material is recent alluvium occupying a first bottom position along streams.

In all, 16 types and four phases were recognized and mapped. Their names and relative and actual extent of each are given in the following table:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington silt loam....	12,607	23.7	Miami silt loam.....	16,128	5.0
Flat phase.....	64,256		Clyde loamy fine sand	6,656	2.0
Clyde fine sandy loam..	54,784	16.9	Miami loam.....	5,248	1.6
Plainfield fine sand....	9,536	14.2	Carrington fine sandy loam.....	4,352	1.3
Rolling phase.....	36,608		Bellefontaine silt loam	4,288	1.3
Clyde silty clay loam ..	33,472	10.6	Muck.....	3,520	1.1
Heavy Phase.....	832		Genesee fine sandy loam.....	3,328	1.0
Miami fine sandy loam	24,064	7.4	Bellefontaine loam....	1,856	.6
Carrington loam.....	3,904	7.2	Fox fine sandy loam..	1,664	.5
Flat phase.....	19,328				
Clyde loam.....	18,048	5.6	Total.....	324,480	.....

Miami Silt Loam.

The soil of the Miami silt loam to a depth of 6 to 10 inches is a light grayish-brown silt loam. It is smooth feeling and has a fairly friable structure. The subsoil is a yellow or light yellowish-brown silt loam grading into silty clay loam at about 20 inches. This in turn becomes a compact, gritty, yellowish-brown clay loam at some point above three feet. The lower subsoil and substratum are moderately calcareous. The substratum to great

depths consists of unconsolidated and unweathered glacial debris containing boulders, rocks, sands, and clays.

Two phases of this type exist in White County, though not in sufficient areas to warrant separation. One phase occurs in flats, and is characterized by the light gray color of the soil. When dry the surface is almost white. The subsoil is mottled with gray and yellow, and often becomes a compact, impervious silty clay at 24 to 30 inches. The other phase is noted along the valley slopes where the topography is more rolling and the soil is oxidized to greater depths. The color becomes as that of the Bellefontaine soils.

Miami silt loam is confined to the southern half of the area, and occurs along the Tippecanoe River and the lower courses of the larger creeks. It includes part of the land east of Monticello and south of the Pennsylvania Railroad, as well as a few isolated areas in the southwestern corner of the county. All of the type formerly supported a growth of hickory, oak, maple, walnut, etc. timber.

The typical topography is gently undulating to rolling. There are ridges with intervening areas of black land and level land dissected by streams.

This type has better natural surface drainage than any other soil in the area except the Bellefontaine types. All of the rainfall can readily flow into adjacent depressions or into the streams.

Miami silt loam was the first soil put to agricultural use in White County. While not very extensive in this area, it includes some of the best farms, and is valued highly. About 90 per cent. of the type is cultivated, and the remainder is a valuable asset for the firewood and pasturage it furnishes.

Corn is the principal crop in this soil, but it is recognized to be one of the best soils for timothy, wheat and clover. Oats are also largely grown. These five constitute the only crops grown on a commercial scale. A number of apple orchards were observed on this type, but with one exception they are neglected and return little income. The trees make good growth and the indications are that fruit growing might be made profitable on this soil.

The light color of the Miami silt loam indicates that humus and nitrogen are probably lacking. The practice of keeping livestock to help supply these elements is general. The usual quota of hogs are found, and more cattle are fed on "clay" land farms than elsewhere. The farmer tries to raise clover and pas-

ture cattle periodically, and spreads all the manure from barns and feed lots on the thin land. Some of the rougher areas of this type along streams are in permanent blue grass pasture. Some sheep are raised and fed. Several of the dairies supplying milk to Monticello and other towns are located on Miami silt loam.

Where the growth of legumes and feeding of stock have kept up the fertility, the Miami silt loam produces larger crops than the average of the county. Corn will average 35 to 40 bushels per acre, and may range to 75 bushels in extra good seasons. Wheat produces about 20 bushels under average conditions, and occasionally doubles that amount in some fields. Oats usually return 35 bushels, but the strength of the soil was shown in the exceptional season of 1915. Then some fields of Miami silt loam yielded over 75 bushels per acre in spite of severe damage in the shock. Hay yields of both clover and timothy are usually one ton per acre. Rye is occasionally sown, and returns about 15 bushels. One field of rye and vetch was observed on Miami silt loam. When cut to hay it yielded over two tons per acre. Most of it was plowed under to improve the soil.

Miami silt loam requires and receives rather careful treatment. Although the natural surface drainage is good, the subsoil is tight, and tile drainage pays. The land will clod if trampled by stock or plowed when too wet, but can be kept in good tilth when rightly cultivated. Some commercial fertilizer is used with corn or drilled in with wheat or oats. From 100 to 200 pounds are used of mixtures containing 2 per cent. nitrogen, 8 per cent. phosphoric acid, and 4 per cent. potash. Other formulas are 2–10–2, 2–10–4, 2–8–2, etc. Most farmers prefer to build up their land by legumes and manure.

Miami silt loam is worth from $125 to $300 or more per acre, according to farm improvements and distance from town. Little land of this type is now changing hands. Two farms containing this soil sold in 1915 at $145 and $150 per acre.

Further improvements of this type of land can be brought about by more general extension of the methods used by the better farmers. Some of the flat fields would be benefited by tile drainage. Even more livestock should be fed and dairying engaged in when possible. The manure is a cheaper source of nitrogen than commercial fertilizers, and also supplies organic matter and potash. It also has some effect in correcting soil acidity. Tests by the Indiana Experiment Station show that this type is usually slightly acid. Application of 1,000 pounds or

more per acre of agricultural lime should help the land, especially in insuring a "catch" of clover. It is very necessary if alfalfa is to be grown. Cowpeas and soy beans might be used where clover fails. Experiments at Purdue indicate that stubble ground can be disced or plowed immediately after wheat cutting, and sown to cowpeas. They usually will yield nearly a ton of hay in the fall or can be pastured and plowed under. Fertilizer tests show that phosphoric acid is the element most needed in Miami silt loam. Potash is usually beneficial, and nitrogen may be so on thin soils. Wheat nearly always yields good returns from applications of 200 pounds per acre of 4–8–4 or 0–8–4 goods, but the results with corn are variable. Its yields are more often limited by factors other than the amount of plant food in the soil.

Miami Loam.

The soil of the Miami loam to an average depth of 8 inches is a light grayish-brown loam or silty loam. The subsoil is a light yellowish-brown heavy loam, grading into silty clay loam or clay, usually somewhat mottled with gray and brown. The substratum is unweathered glacial till somewhat calcareous. As it occurs in White County, this type is transitional between Miami silt loam and the sandy soils of the county, and is quite variable in color and texture. The surface soil ranges from gray to brown, and includes small areas of fine sandy loam and silt loam. The subsoil is always heavy, and sometimes is very compact and impervious and gray in color. The areas with a light grayish soil and a gray subsurface layer are really the Crosby loam, but they are too limited in extent to justify a type designation.

The largest amount of Miami loam is found in a large irregular body just northeast of Monticello. Other areas are located throughout the timbered land south of Monticello, and also along the junction of the sandy and "clay" lands. Hardly any of this type occurs in the northern half of the county.

The topography ranges from level to gently rolling. Some narrow belts of steep valley slopes are included. It often occupies slight rises above the adjoining types of soil.

The natural surface drainage of this soil is good to fair because of its elevated position or proximity to water courses. The flat areas with tight subsoils have been much improved by open ditches and tile drains.

The Miami loam comprises a small per cent. of White County, but is well improved and fully utilized.

It corresponds closely to Miami silt loam in almost every detail of use, needs, yields, etc. Corn is the principal crop, and oats, too, are grown, but wheat and clover do better on this soil than on black land.

Considering the small extent of this type, it is relatively important in the livestock business. Hogs and cattle are fattened, and several dairies are located on this type. The manure is a large factor in keeping up the fertility of this soil.

The crop yields about equal those of Miami silt loam. Corn and oats will average 35 bushels, wheat 20 bushels, and clover 1 ton of hay and a bushel of seed per acre, but these yields are occasionally doubled in good seasons.

Miami loam is probably slightly easier to cultivate than the silt loam, because of the more sandy surface soil, but is handled, fertilized, etc. in practically the same way.

This is a valuable type of land because of its productiveness, and since much of it is located close to towns. Not much of such land is on the market. Two farms consisting of this type and some black land sold for $111 and $150 per acre in 1915.

Some well-improved places near town could not be bought for $200 per acre. Many areas of this type are small, and their value depends much on the value of the surrounding types.

The suggestions for the improvement of Miami silt loam apply equally well to the loam.

Miami Fine Sandy Loam.

The surface of Miami fine sandy loam to an average depth of 7 inches is a grayish-brown fine sandy loam or loamy fine sand. The first inch or two is often dark colored. The subsoil is light brown or yellowish-brown fine sandy loam passing at about 18 inches into yellowish-brown, sticky, fine sandy loam or clay loam. In some places the substratum is heavy glacial till and elsewhere it consists of sandy materials. In a few instances this soil may be derived from the weathering of sandy till, but in most instances seems to be the result of sands from the lake region drifting over the heavy glacial ground moraine. Many of the areas in the northern part of the county have deeper sandy soils, sandy clay loam subsoils and deeper sand substratum. A few such areas might have been mapped as Dunkirk fine sandy loam if they had occurred more extensively.

The most extensive development of this type occurs along the southern border of the lake plain and along the upper courses of

the Tippecanoe River. Some areas are found in the timbered country south of Monticello, and small ones are scattered throughout the northern portion of the county. The topography of this type is level to undulating, and the areas are elevated slightly above the adjoining black land. The natural drainage is fair and artificial drainage has usually been supplied where necessary.

This soil is fairly extensive and important in the northeastern quarter of the county, as it is the best of the light-colored sandy soils. Probably 85 per cent. is cultivated.

Corn, wheat, and oats are the principal crops grown on this soil. It is often difficult to get a good stand of clover on such land.

Some of the Miami fine sandy loam is included in stock farms, and is much benefited by the manure dropped in the fields or carried and spread from the barns.

Fair average yields of corn and oats are 30 bushels per acre, though in the best seasons some fields produce 50 bushels per acre. Wheat will average 15 bushels and sometimes does much better. When a growth of clover is secured, the hay yields approach 1 ton per acre.

This type of land is easy to cultivate, and does not clod or get in bad condition when plowed wet. It responds quickly and greatly to applications of manure and to plowing under of any kind of organic matter. Rye is sometimes used as a green manure. Applications of 100 pounds to 150 pounds of complete fertilizer are generally used with wheat and corn. It helps give the corn a good start, especially if planting has been delayed.

This type is usually intermingled with black sandy land, so the land values depend on the relative proportion of the two and the distance from town. Ten farms in the county containing more or less of Miami fine sandy loam were sold in 1915. The average size of the farms was 116 acres, and the average price was $120 per acre.

Practices recommended for other Miami soils would be equally beneficial on the fine sandy loam. The abundant growth of red sorrel on much of this type indicates an acid condition, which is borne out by analyses made at Purdue. Tests show that from 300 to 4,000 pounds of ground limestone would be required to neutralize the acidity of an acre-foot of some light sandy soils. Liming would aid the growth of leguminous crops which should furnish humus and nitrogen to the soil. Limited amounts of soluble phosphoric acid and potash should prove profitable.

Bellefontaine Silt Loam.

The soil of the Bellefontaine silt loam is a brown, friable silt loam grading at about 10 inches into bright yellowish-brown to reddish-brown silt loam, which passes in turn into reddish-brown silty clay loam. Between 20 and 30 inches the subsoil becomes a compact gritty or gravelly clay loam and the substratum is quite gravelly or stony till, carrying a high percentage of limestone material. Sometimes it is partially stratified. Gravel pits are often located in it.

Bellefontaine silt loam is confined to the timber belt east of Brookston and Chalmers. The topography ranges from smooth rolling to undulating. Although uneroded, the surface is more uneven than that of other land in the county. The drainage and aeration of this type are good because of the topography and the gravelly substratum, besides a general proximity to streams. The gravel is not near enough the surface to make it droughty.

This type is derived from the weathering of glacial debris piled in terminal moraines, and from ground moraine in advanced stage of oxidation. It was originally forested.

This is commonly called "chocolate clay land," and is generally valued more highly than "white or yellow clay" soils classed in the Miami series. Eighty-five or 90 per cent. of the type is cultivated, and the remainder is in woodlots and pastures. The total acreage in White County is relatively small.

This soil is handled in practically the same way as the Miami silt loam. Corn, oats, wheat, and clover are grown, and livestock business is relatively important. The natural productivity and value of the Bellefontaine silt loam may be slightly greater than that of the Miami.

Although this land is well improved, it might be further improved along the lines suggested for Miami silt loam.

Bellefontaine Loam.

Bellefontaine loam is a light brown to reddish-brown loam or silty loam 10 inches deep. The subsoil is a reddish gravelly clay loam or clay, becoming more gravelly and looser in the lower subsoil. The substratum is gravelly or stony till like that underlying the Bellefontaine silt loam. The land was timbered.

The principal areas of the type are scattered through the rougher timbered land around Brookston and Chalmers. The long and very narrow strips mapped along some creeks and the

Tippecanoe River, as far north as Norway, represent erosional belts of very steep topography sloping from the plains to the stream bottoms. Other areas occur on the rougher slopes of the moraines, and a few are relatively smooth, but with light-textured surface soils. The surface drainage of this type is good to excessive, and some steep slopes are subject to erosion.

The type is very limited in extent, and about 50 per cent. of it is not cultivated.

Corn, wheat, oats, and rye are grown on the smoother areas of this type. The steep stream slopes are in timber and brush or pasture.

About half of this type is better suited to pasture than any other. All classes of farm animals range on it.

Corn and oats yield 20 to 25 bushels per acre under average conditions. Wheat and rye average 10 or 12 bushels.

Areas of Bellefontaine loam are usually so small that they are handled and fertilized just like the adjoining soils if they are cultivated at all.

This type usually forms a small proportion of farms, so is included in a general valuation of $100 to $150 per acre.

Most areas of this type might best be devoted to grasses, hay and wheat and rye, rather than corn and oats. Alfalfa or rye and vetch would protect the land from erosion and improve the soil. Some areas would make good locations for woodlots or orchards.

Many gravel pits are located on this and other Bellefontaine soils. The gravel contains considerable clay, and makes better roads than that from "white gravel pits," but is usually not so well adapted to concrete.

Carrington Silt Loam.

The soil of the Carrington silt loam is a dark brown to nearly black mellow silt loam, averaging 10 inches deep. When wet it is black, and the dry surface of plowed ground is quite brown. The subsoil is a brown silt loam passing into lighter yellowish-brown silty clay loam, which becomes slightly gritty below 30 inches. The substratum is grayish, slightly calcareous boulder till, with local spots of sand and gravel.

This type of soil is found only in the prairie region of White County, the principal areas occurring on the smooth, morainic ridges of Round Grove, Prairie, West Point, and Big Creek townships. The topography varies from gently undulating to rolling,

but is all well adapted to use of farm machinery. The type is naturally very well drained, although the flatter areas have been improved by tiling.

This is the first type of soil which was farmed in the prairie, as there was no danger of crops drowning out even before ditches were dug. Probably every acre of such land is in cultivated fields or farm yards.

Corn and oats are the principal crops grown on Carrington silt loam. Clover is sometimes sown and cut for hay if a good stand is secured. Wheat and other crops are rarely seen on this soil.

Hogs are kept on most farms, and some cattle and sheep are being fed in larger numbers than formerly. Dairying is undeveloped.

Corn and oats will average over 35 bushels per acre on Carrington silt loam. These two crops have been grown exclusively on some fields for over 50 years, with no commercial fertilizer and little manure or clover. In such cases the average yields have decreased 5 or 10 bushels per acre. On farms raising livestock and sowing clover occasionally the crop yields are maintained at a high level. Farmers are beginning to realize that this land can wear out, and are making efforts to bring up their crop yields in proportion with the high valuation of the land. Some commercial fertilizer is applied to the corn crop by means of the planter attachment.

An average valuation of Carrington silt loam is from $150 to $250 per acre, according to improvements and location. Few farms are being sold. Two tracts transferred in 1915 brought $140 and $217 per acre respectively. Some other types of black prairie land were included in these farms.

Carrington silt loam should and could be made more productive than it is on many farms. Although the land is black and contains much organic matter, either livestock or clover should be used to put available nitrogen into the soil. Fertilizer tests as well as analyses indicate that phosphoric acid is the most deficient plant food in these soils. One hundred to 200 pounds of fertilizer containing 8 to 10 per cent. phosphoric acid and 2 to 4 per cent. of soluble potash will usually give a profit with corn. While the same fertilizer will increase oat yields, the value of oats per bushel is not great enough to insure a profit over the cost of the fertilizer. However, it will aid in getting a stand of clover on the oat ground. Raw rock phosphate gives

fairly satisfactory results two or three years after it is applied. Acidity tests show that this soil is neutral or only slightly acid. Limestone would not be needed for most crops, but in the thinner ground would benefit clover or alfalfa.

Carrington Silt Loam—Flat Phase.

This phase differs from the typical Carrington silt loam by having blacker soils of greater depth, which averages 14 inches. The subsoil is grayish-brown or mottled brown, gray and yellow heavy silt loam or silty clay loam. The brown mottlings usually become more distinct and plentiful with depth, and the texture lighter and slightly gritty below 30 inches. Although the mechanical analysis shows little difference between soil and subsoil, the latter has a stiff and semi-plastic structure like a silty clay. The substratum is a stony till, and in places there are strata of sands, gravel, blue clay, etc. As mapped in White County, this classification includes small or indefinite areas of Clyde silty clay loam and also slightly better drained spots where the subsurface is solid brownish-gray and the deeper subsoil is mottled with gray. It is seldom possible to draw a sharp boundary between this phase and the typical Carrington silt loam on the one hand and the Clyde silty clay loam on the other.

The type is limited to the prairie region of the southern half of the county, and also around Wolcott, where it resembles and blends into the Carrington loam. The topography is very flat to very gently undulating, with a few small rises and depressions. The drainage is naturally quite poor. Some areas were quite marshy in rainy seasons. Now the type is well provided with dredged outlets and with thousands of rods of tile drains, so that crops are in no danger of drowning out.

This is the most important and extensive soil type of the prairies, and one of the most important in the county. It is entirely utilized for agriculture.

This phase of Carrington silt loam is devoted to the production of corn and oats. Only a few farmers attempt to grow clover or any other hay crop. Sometimes small pastures are provided for work stock, but they are usually turned out on stubble or in stalk fields.

For some years the livestock business was neglected on the prairie, but there is a tendency now to feed more cattle and sell less of the crops.

This type of soil yields 40 bushels of corn and oats under

average conditions, and many farmers are not satisfied with less than 60 bushels. The season is the largest factor in determining results.

The average size of prairie farms is large and the land lies ideally for carrying on operations on a big scale. Gang plows, two-row cultivators, and other large-sized implements make up for the deficiency in labor. The land is broken deeply and well cultivated. Corn is usually kept clean, though this is difficult in very wet seasons. In a few fields, gopher vine, smart weed, and other bad weeds are giving much trouble. Commercial fertilizers are not used, and little effort is made to keep up soil fertility. Up to the present date, the crop yields maintain a very high average without applying any plant food. Because of the poor drainage in early days, much of this soil has not been farmed regularly over 25 years, and some virgin sod was broken less than 15 years ago.

In recent years the valuation of this land has risen to very high figures, and trading was brisk, though little prairie is on the market at the present time. Six farms consisting of Carrington silt loam—flat phase and Clyde silty clay loam were sold in 1915. They averaged 140 acres in size and brought from $97 to $228 per acre. Six farms containing flat phase associated with Carrington loam sold at lower average figures. Land values of this type in Round Grove township may be slightly lower by the distance from railroads.

Where the Carrington silt loam-flat phase has been well tiled, it is a fine soil needing little improvement. It is new land of great lasting qualities. However, experience proves that any soil will "wear out" if cropped exclusively to corn and oats, so sufficient manure and legumes should be put in the soil to keep it up. Since the land is valued so highly, ordinarily good crops do not return much interest on the amount of money invested. Therefore the land should be farmed more intensively and an effort be made to bring it up to the standards set by Boys' Corn Clubs, and so make farm operations really profitable.

Carrington Loam.

The soil of the Carrington loam consists of a black loam of variable texture about 12 inches in depth. The subsoil is yellowish-brown, brown and gray heavy loam or clay loam becoming lighter textured and brighter colored with depth. The surface soil may effervesce slightly with acid, while the subsoil usual y

gives a strong reaction indicating the presence of calcium carbonate in considerable quantities. In local spots the soil mantle is only 2 or 3 feet deep, and rests directly upon limestone, and throughout the type limestone forms a substratum at depths of 20 feet or less.

The main development of the Carrington loam is in Monon township. Between and along Big and Little Monon Creeks, where erosion has removed more of the old lake plain deposits, the bed rock is within about 8 feet of the surface. Experienced tile ditchers say that there are probably 100 acres of land in this neighborhood where the depth to rock averages 30 inches deep, but the substratum was very seldom encountered with a 3-foot soil auger. The rock is revealed in several dredged ditches, by outcrops along the creeks, and in the stone quarry just south of Monon. The rock does not seem to be weathered, and the overlying soils do not seem to be residual. Glacial boulders occurring on the surface of the land are granitic, not limestone.

The topography of this type is level to gently undulating. It was originally a moist prairie except for some thinly timbered areas near the creeks. The surface drainage was fair, and is now improved by dredged ditches and tiling. In places it was necessary to blast the limestone from the ditch bottoms, and rock sometimes interferes with tiling operations.

Although a prejudice exists against land with rock bottom, it seems that only a very small per cent. of it is really seriously injured by having too shallow a soil. Corn is the crop most likely to suffer. The type is mostly under cultivation.

Corn, oats, and some wheat are grown on this land. Probably more use is made of clover and livestock here than on the typical Carrington loam of White County.

Thirty to 35 bushels of corn and oats are considered average yields for a term of years. The better farms produce much larger crops. Twenty bushels is a fair yield of wheat, but some fields produced 40 bushels per acre in 1915.

This soil is handled like the other heavy-textured prairie types, but more commercial fertilizer is needed and used.

Most of the Carrington loam is located near towns, and the value is increased thereby. The farms are valued between $100 and $175 per acre.

Increased use of clover and livestock are the principal needs of this soil, but fertilizers containing soluble potash and phosphoric acid will doubtless be profitable.

Carrington Loam-Flat Phase.

The soil of the Carrington loam-flat phase is a dark brown to almost black mellow loam from 12 to 16 inches deep. The subsoil is a brown loam grading quickly into a yellowish-brown clay loam mottled with gray and brown. Sometimes there is a slight veneer of fine sand on the surface, and the sub-stratum may be sandy. This type grades gradual y into the adjoining Carrington silt loam and fine sandy loam, so that no sharp boundary can be drawn.

Carrington loam is a prairie soil occurring most largely around Wolcott, where it is partially surrounded by the fine sandy lake plain soils.

The topography is flattish to gently undulating. In this respect and in the gray mottling of the subsoil it is not typical of the Carrington series. The Carrington loam-flat phase occurs far from any natural waterways, and was once insufficiently drained, but all surplus water is now removed by tile drains and open ditches.

Apparently this loam was formed by the admixture of sand thinly spread over the formerly silty prairie. In a few areas scattered in the southern part of White County, it may be the result of weathering of sandy glacial till.

This soil type is quite important, though relatively inextensive in White County, and includes almost no waste land.

Like the other prairie soils, it is used principally for corn and oats, though a few farmers grow clover and raise livestock.

In crop yields it equals Carrington silt loam.

This type is handled like the other prairie sil. The sandy or loamy surface soil is easier to plow and cultivate but is practically as strong and lasting as the silt loam.

The value of Carrington loam-flat phase is slightly depreciated by association with poorer sandy lands, but 8 or 10 farms consisting largely of that type were sold in 1915 at prices ranging from $62 to $175 per acre.

On a certain farm near Wolcott one field of Carrington loam was reported to average 40 bushels of corn per acre after many years of cropping to corn and oats, and with the occasional application of manure. An adjoining field received no manure and now averages only 25 bushels of corn per acre. This case illustrates how this soil *should* and should *not* be treated. Suggestions offered for improving other Carrington soils apply also to the loam.

Carrington Fine Sandy Loam.

This type is a dark brown, mellow or loose fine sandy loam averaging 14 inches deep. The subsoil is a brown fine sandy loam or loam grading into a yellowish-brown fine sandy clay loam. Sometimes the sandy layer is over three feet deep before the heavy subsoil is encountered. The substratum is till, which is sometimes of a sandy nature. Some of the areas around Monon and Lee are underlain by limestone at shallow depths.

The Carrington fine sandy loam occurs around Wolcott and in some spots of well-drained sandy prairie scattered through the lake plain in the northwestern portion of the county. The topography is level to gently undulating. Some areas are low, gentle rises above the surrounding prairie, and others are transitional between the heavier prairie and the sandy lake plain soils. The drainage is usually good, due to its position and fairly porous structure.

This type is the most inextensive and poorest of the prairie soils, especially where the sands are deepest. Where it approaches and blends into the Carrington loam it has almost equal value. It is largely utilized for farming.

Corn, oats, and occasionally wheat and clover are the crops grown on this type.

Livestock raising and feeding and dairying are not important on Carrington fine sandy loam.

Crop yields will probably average somewhat lower on this type than on Carrington loam unless it is kept up by manure and legumes. The areas with a limestone substratum are slightly more productive than the general run of the type.

Land of this type is handled like other prairie soils. It is easier to cultivate under wet conditions than the heavier soils. Fertilizers and manure are not largely used.

The value of the Carrington fine sandy loam varies greatly with the character and proportion of associated soils. It ranges from $60 to $150 when mixed with Carrington loam.

This type of land is well adapted to corn, as it is warm, deep and mellow. However, it is more droughty and not so strong and lasting as other prairie soils. Yields could be profitably increased by use of manure or legumes and fertilizer containing soluble phosphoric acid and potash. This is a good trucking soil, and might be more used for potatoes, as the home markets could consume most of the crop. Purdue recommends 500 pounds of

fertilizer per acre for potatoes. It should contain 2 per cent. nitrogen, 10 per cent. phosphoric acid, and 6 per cent. potash.

Clyde Silty Clay Loam.

The surface soil of the Clyde silty clay loam is a black silty clay loam 16 inches deep. At the immediate surface it is usually friable to loose, due to organic matter, and just above the subsoil it typically becomes more densely black and slightly plastic. This passes quickly into a grayish silty clay loam to silty clay. The lower portion becomes mottled more or less with rusty brown and yellow. The substratum may be grayish heavy till or may be beds of brownish sands and fine gravel as shown at the clay pits west of Chalmers. The subsoil is somewhat calcareous, and small white lime concretions occur. Where associated with Miami soils, the boundaries of this type are usually sharp, its surface is rather grayish-black, and the average texture of the soil is heavy. In the prairie region the boundaries between the flat phase of the Carrington silt loam and Clyde silty clay loam are often arbitrary as they grade gradually into each other. There is often more structural than textural difference between them.

Most of this type is located in the southern half of White County, intermingled with the Miami and Carrington soils. Some areas occur north of Reynolds and elsewhere in the sandy lake plain. The topography is very flat and slightly depressed below the surrounding soils. The type was formerly marshy and covered with water a portion of the year, but most of it is now traversed by dredge ditches, open and tile drains, so that crops are insured in wet seasons.

The Clyde silty clay loam is one of the strongest and best soils of White County and all central Indiana. All of it is used for cereals, hay or pasturage.

Corn and oats are the main crops grown, with an occasional field of timothy and clover. Some of this type supports blue grass pasture, which is highly valued by stockmen. Animals are grazed and fed on this land, more because of the heavy growth of grass than for the purpose of improving the soil.

On well-tiled farms this type is expected to yield 40 bushels of corn and oats per acre. In exceptionally wet seasons it may not do so well as the Carrington silt loam. Clover does very well if a good stand is secured, and it does not winter kill. Sev-

eral fields of little red clover observed in 1915, promised to yield nearly 2 tons of hay per acre. Clover seeded the same spring caught very well. Timothy hay makes a rank growth and sometimes yields over 2 tons. Average yields of all crops may be doubled in best seasons.

Since Clyde silty clay loam has been generally drained it is handled like the Carrington soils. Great care must be taken to avoid putting it in bad physical condition by plowing when too wet. Cultural operations are more difficult than on lighter and more loamy land. Most of the land is new, and fertilizers are not used.

Well-drained Clyde silty clay loam is some of the highest-priced land in the county. It comprised part of 10 farms sold in 1915 at prices ranging from $100 to $228 per acre. Much of this soil lying west of Chalmers could not be bought for $250.

Some areas of this soil can be improved by more thorough drainage. Sometimes so-called "bogus" or "alkali" spots are found in this and other heavy prairie soils. They are characterized by white incrustations of salts on the surface, and by the poor growth of corn. The salt is probably lime sulphate in most cases. Chemical analyses and fertilizer experiments by Purdue indicate that the bogus condition is caused by acidity and lack of available phosphoric acid and sometimes of potash. These elements should be supplied in fertilizers. Applications of straw and manure and better drainage are also beneficial. Liming may be needed in these spots, but the bulk of Clyde soils are alkaline or neutral. A very good field of alfalfa east of Chalmers on this land suggests that a greater acreage of that valuable forage should be sown. All the farmers should follow the examples of the leaders and keep the land built up by legumes and livestock.

Clyde Silty Clay Loam—Heavy Phase.

This phase consists of black silty clay about 12 to 20 inches deep. Sometimes the immediate surface is slightly lighter textured. The structure is fairly plastic and smooth, and when dry the clay becomes very hard and cracks deeply. Sometimes it passes quickly from a very black soil into light gray subsoil, and again it grades through a drab silty clay into gray mottled with rusty or reddish-brown plastic, sticky clay. Lime concretions are usually found in the subsoil, which effervesces with acid. The substratum consists of gray clays, till, and often brownish sandy strata.

This phase differs from the typical Clyde silty clay loam only in texture and drainage conditions. It is found in a few small areas north and northeast of Chalmers. The topography is flat, as this soil occupies the lowest part of the depressions which are largely the silty clay loam. The drainage s not so good as on the silty clay loam, but much of it is ditched and tiled.

It is very limited in extent, but is valuable for corn, oats, and pasture. It is more intractable, but is priced as high, yields as much, and will probably prove more lasting than the silty clay loam. The crops grown and methods employed are common to the prairie land. Early maturing varieties of corn should be planted on this and all Clyde soils, because they are moist and rich in nitrogen, so that the growth continues dangerously near frost time, which comes early in low ground.

Clyde Loam.

The soil of the Clyde loam is a black loam of variable texture, and about 13 inches deep. Often the surface is a fine sandy loam, or may be slightly mucky. Below, the soil is a drab clay loam, passing quickly into light gray semi-plastic and sticky clay loam mottled slightly with brown. In areas of the southern and central portion of White County the deep subsoil and substratum are usually grayish mottled clay loam and clays and stony till. It is calcareous. In the northern portion of the county well within the lake plain the substratum is usually sandy.

Most of this type occurs north of the Pennsylvania Railroad and west of the Tippecanoe River, though some areas are found northwest of Idaville and also scattered in the southern part of the county. The topography is flat and the surrounding land is somewhat higher. The drainage was naturally poor, and some areas need an extension of the general system of ditching and tiling. The type includes typical lake marshes and also prairie land, which was veneered with a little sand and encircled by sand ridges so that rainfall could not escape. Some borings bore a close resemblance to Carrington loam—flat phase.

Clyde loam is often called "willow land." It includes much of the best soil of the lake plains, although thorough drainage was necessary before crops were sure. It is fairly extensive in Honey Creek township. It is all used for cereal and pasture.

Corn and oats are the principal crops grown on this type. The acreage of wheat and clover is very limited.

The type was formerly devoted to grazing and marsh hay, but

now only the wettest portions are generally used for those purposes. Some cattle are raised and fed on Clyde loam.

Very good average yields of corn and oats are now secured. In ordinary and dry seasons this land will surpass much of the prairie land, but excessive rainfall drowns out some of the lowest fields. Some of the best yields are 70 bushels of corn and oats and 35 bushels of wheat per acre, while half those amounts represent average conditions.

This type is handled and fertilized just like the other black lands of the county where grain growing is the dominant industry.

Trading in this kind of land was fairly brisk in 1915. Eight large farms consisting of this type and Clyde fine sandy loam sold at $90 to $210 per acre. In several other farms which included some light sandy land the prices ranged from $85 to $130 per acre, and two farms of Clyde and Miami loams brought $111 and $150.

Much of the Clyde loam could be further improved by deepening drainage outlets and laying tile 50 to 100 feet apart. "Bogus" spots and mucky areas should be fertilized with potash and phosphoric acid. Straw and manure are also useful, but they are needed more on light sandy land. Early maturing varieties of corn should be grown to avoid danger of early frosts. Seed should be selected from mature plants before the general harvest time, and stored in a dry place for the winter. It would doubtless be found profitable to grow more legumes and utilize more of the grain in the production of beef or pork.

Clyde Fine Sandy Loam.

The surface of this type is a black fine sandy loam or loamy fine sand 10 to 15 inches deep, and the subsoil is a light drab sticky fine sandy loam or loam mottled with brown and drab and grading into loose fine sands below 30 inches and in the substratum. Along the lower border of the lake plain the subsoil and substratum are often of heavier glacial till.

This type is confined entirely to the lake plain region of White County, where it is found in nearly every section of land. The surface is very flat and lower than that of the light sandy soils around it. The drainage is now generally good by means of many ditches and lines of tile. Some areas remain in the former marshy condition. Although the substratum is very porous, the water table stands near the surface and keeps the land from being droughty.

The Clyde fine sandy loam is the most extensive and important type of lake plain in White County as well as of northwestern Indiana. In this area probably 85 or 90 per cent. is cultivated, while the remainder is used for pasture and marsh hay. Eventually, all will be used for tame crops.

Corn and oats occupy the largest acreage of this type. It is about the best of the light-textured black lands for wheat, and some of that grain is sown. Clover, rye, timothy, and buckwheat are rarely sown.

Before the land was drained the Clyde fine sandy loam was used principally for marsh hay and pasture. It is still used for that purpose by a number of stockmen. Large herds of feeding steers were observed on this type in 1915. One farm was carrying 1,000 head of hogs besides several carloads of cattle.

It is claimed by some farmers that the black sandy land will give better yields than the prairie soils in dry seasons. However, they were never sure of a crop until the big dredged ditches were dug. Now corn and oats average 30 bushels, wheat 18 to 20 bushels, and timothy 1 ton per acre.

This land is handled like the other black lands devoted to corn and oats. The land used for cattle is usually in permanent blue grass or marsh grass pasture. The land can be plowed very wet without injury to the tilth. Potash fertilizer is applied to corn, especially where the surface soil is mucky. Kainit is preferred because it is thought to ward off certain insects.

Over 45 farms of White County which were sold in 1915 were partially comprised of Clyde fine sandy loam. Two farms composed entirely of this type brought $150 and $187 per acre. When associated with Clyde loam and a small proportion of light sandy land, a dozen farms sold for $90 to $210 per acre. Mixed with Miami fine sandy loam in 10 instances it brought from $50 to $163 per acre. In 20 farms it was mixed with Knox fine sandy loam, and in most cases the price per acre was $50 to $100, although several of the best places went at $125 or more. More trading is done in this than any other type of land.

In much of the Clyde fine sandy loam the prime need is still more thorough drainage. Experiments were made by Purdue on a somewhat "bogus" field of soil northwest of Monon. The result of fertilizing oats showed that potash was badly needed, and phosphoric acid was beneficial, but it was useless to apply nitrogen. Acidity tests show this black sandy land to be neutral or alkaline in most cases. Experiments with corn have shown

10 to 20 bushels per acre increase from use of potash on the mucky phases of this type. The quality of the grain is also greatly improved by proper fertilization.

Clyde Loamy Fine Sand.

The surface of this type is a dark gray to black loamy fine sand or fine sand averaging 14 inches in depth. It usually contains 6 per cent. or more of organic matter derived from marsh grasses. The subsoil is a gray or brownish gray loamy fine sand quickly becoming a light gray loose fine sand. The substratum is loose, grayish and brownish sands to considerable depths. Sometimes the better phases of this type have a silty layer a few inches thick in the subsoil.

An acid phase of this type is very slightly developed in White County. It occurs especially along the line of contact with Dunkirk fine sand and Knox fine sand. It is characterized by a more shallow and grayish soil and more brownish mottlings in the subsoil. Dewberries and huckleberries are commonly found on this phase, and there is often a thin growth of pin and black jack oak.

Clyde loamy fine sand is restricted to the northern half of the county in the sandy lake plain region. The largest and most typical areas occur in the northeastern corner of the county. This type is associated with Knox fine sand and Dunkirk fine sand.

The topography of Clyde loamy fine sand is flat to very gently undulating. This soil occupies slightly depressed areas or marshy flats surrounded by sandy ridges, so the natural surface drainage is quite poor. Although the subsoil and immediate substratum are quite porous, there are impervious strata at lower depths, which keep the water table near the surface (about 36 inches to 50 inches), and make this nondroughty soil. At the present time artificial drainage has been provided for most areas of Clyde loamy fine sand.

This type includes the poorest of the black lands, and is relatively inextensive in White County. Probably 60 to 70 per cent. of such soil is now cultivated, while the remainder is used for pasturage. This pasture land usually bears a growth of marsh grasses, and often pin and black jack oaks, quaking aspen, dewberries, blackberries, etc.

Corn and oats are the principal crops grown on this land. Wheat and hay are of secondary importance. Fattening cattle

and the general classes of farm stock are grazed to some extent on this type.

The crop yields on Clyde loamy fine sand have a wide range, according to season and minor variations of the soil. Corn and oats will yield from 15 to 40 bushels, with an estimated average of 23 bushels per acre. Wheat will average about 10 bushels, and hay returns something less than a ton per acre.

At the present time this land is handled and fertilized like the Clyde fine sandy loam.

Some of the better areas of this land are valued almost as highly as the Clyde fine sandy loam, while other areas of lower productiveness, located far from towns, are low-priced. This type comprises part of 11 farms sold in 1915, the prices of which ranged from about $25 to $150 per acre.

The suggestions offered for improvement of Clyde fine sandy loam apply also to the loamy fine sand. However, the latter classification includes more acid land, which requires special attention. Analyses and field experiments show that the sour land would be benefited by applications of limestone and also phosphoric acid. Analysis of a sample taken in S. W. Quarter, N. E. Quarter, Section 25, R. 2 W., T. 28 N. showed that the land was slightly acid and contained only 12 per cent. phosphoric acid and .05 per cent. potash (K_2O) soluble in strong acid. The soil contained 1.03 per cent. potash, but the land is improved by use of this element in a soluble form.

Dunkirk Fine Sand.

The surface of this type to an average depth of 8 inches is a grayish-brown or light-brown fine sand. Sometimes the first inch or two is dark-colored and loamy. The subsoil is a loose light yellowish-brown fine sand, with slight mottlings of gray, which usually become more pronounced with depth. Some spots of land are almost orange-colored. Rarely there may be a thin layer of fine sandy loam in the subsoil, but the loose sands extend to considerable depth.

The Dunkirk fine sand occurs only in the northern and sandy portions of White County. The areas of this soil are of small average size; seldom contain more than 300 acres, and are most abundant throughout Township 28 N. They typically occur in positions intermediate between the black lands and the sand ridges.

The topography is flat to very gently undulating. As the surface is elevated slightly above the marshy land, the type was naturally drained by run off and by downward percolation of water through the loose sands. In some of the flatter areas, where the water table formerly stood too near the surface, the land has been improved by ditching.

It is not so good as the black lands, but is better than the Knox fine sand. It was originally timbered with pin, black jack, red and white oaks, aspen, etc., with an undergrowth of briars, hazel brush, mosses, etc. Probably 80 per cent. of the type is now cultivated.

Corn, oats, and wheat are the main crops grown on Dunkirk fine sand. Livestock incidental to general farming are pastured on the uncleared areas of this type. In 1915 a number of small fields of cowpeas were observed, which were growing fairly well. Some rye is grown.

A fair average yield of corn and oats is 20 bushels per acre, but well handled and fertilized land will do much better. Wheat averages about 10 bushels, and rye about the same. Timothy hay yields about three-fourths of a ton per acre. Cowpeas are still in the experimental stage in White County, but often yield a ton of hay per acre.

Dunkirk fine sand is a very easy soil to cultivate, because it is loose and well-drained. The loose surface forms an effective mulch, which conserved moisture very well in dry weather. It is the general practice to put all the available manure on this land. Also fertilizer is applied for corn or wheat at the rate of 100 to 200 pounds per acre. It usually contains 2 per cent. nitrogen, 8 to 10 per cent. phosphoric acid, and 2 to 4 per cent. of potash. Rye is sometimes plowed under as a green manure.

Dunkirk fine sand sells from $25 to $150 per acre, depending on the proportion of black land and sand ridges in the farm, distance from town, etc. Alone, it should be worth $50 to $100.

Dunkirk fine sand is a soil which can be "built up" and improved in many ways, and could be used more for trucking, although there are no near city markets. According to acidity tests made by Purdue on land of this general character, applications of 300 pounds to 2 tons or more of ground limestone would be necessary to neutralize the acidity in an acre-foot of soil. The abundant growth of dewberries, red sorrel, and cinquefoil indicate the general sourness of Dunkirk fine sand. An analysis of a sample of this soil, taken in S. W. Quarter of N. W. Quarter,

Sec. 25, R. 2 W., T. 28 N., showed less than 2 per cent. organic matter, and .08 per cent. nitrogen. Strong acid extracts gave .06 per cent. phosphoric acid (P_2O_5) and .03 per cent. potash (K_5O), although there was 1.44 per cent total potash. There was .33 per cent. lime and magnesia, but they were not in the carbonate form, and 1,470 pounds of limestone would be needed to correct the acid in an acre-foot. These figures show the great need of organic matter and nitrogen. By liming the land, clover could be grown to supply this deficiency, but cowpeas can be successfully sown on acid land, and are good for hay, grain, pasture, or sil improvement. More use should be made of rye, or rye and vetch for green manure and hay. Where possible, livestock raising or dairying should be followed, and the manure carefully returned to the soil. It will be necessary to supply liberal amounts of phosphoric acid in order to make this soil very productive. Some soluble potash would probably be profitable, but this element is fairly abundant in the soil, and should be made available by the action of decaying organic matter.

Dunkirk Fine Sand—Rolling Phase.

This soil consists of a loose, incoherent light-brown or grayish-brown fine sand loam about 8 inches deep, underlain by light yellowish-brown, incoherent fine sand to considerable depth. It is very uniform in texture, containing over 50 per cent. of fine sand, and practically no particles coarser than medium sand. The surface may be dark in wooded and grassy areas, or light yellow where cultivated or disturbed by the wind. Sometime the subsoil is stained with iron to a reddish or bright orange color.

The Dunkirk fine sand—rolling phase—occupies the broken dividing ridge which separates the southern, silty half of White County from the northern or sandy half. It is found throughout the latter region. Some of the largest and most characteristic areas are situated in Cass township.

This soil typically occupies ridges from 3 or 4 to 40 feet or more above the surrounding land. One side of the ridge always is rather steep, and the other side is a more gradual slope. This type appears to have been formed by wind action from the same material as the Dunkirk fine sand at the time when the land surface was not protected by vegetation. Some of the larger ridges may have been glacial moraines, but such material is now deeply covered with loose fine sand, and no rocks or gravel are observed

on the surface. Topographically, this soil grades into the Dunkirk fine sand. Some of the broader areas of Knox fine sand are not distinct ridges, but rather a series of choppy or billowy knolls, which stand higher above the general water table than the typical Dunkirk areas.

On account of its porous structure and elevated position, this phase is well to excessively drained.

The droughtiness, roughness, and low fertility of this land make it the least desirable soil in White County. About half of it is cultivated, and the remainder is in scrubby oak timber and pasture.

Corn is the principal crop grown on this phase. Rye, wheat, oats, and cowpeas are also observed on the ridges. Rather poor pasture is afforded for all kinds of farm stock.

It is estimated that corn will average 10 or 15 bushels per acre, and other crops in proportion. On the flatter areas and in wet years the yields will almost equal the normal returns of Dunkirk fine sand.

This land is handled like the Dunkirk fine sand, though it is not thought worth while to expend much effort with it, and fertilizers are supposed to be depleted by leaching. More corn is grown because cultivation conserves the moisture very well. Rye is used to protect the land from blowing, and to furnish organic matter.

Small areas of Dunkirk fine sand—rolling phase—are valued for building sites on black land farms, but places composed largely of this type are worth from $20 to $75 per acre.

The practices suggested for the improvement of this phase would also help the Knox fine sand, although the latter would always remain rather droughty. However, even in dry weather a well-cultivated sand ridge seems to have plenty of moisture below the surface, so if the rains are well distributed the greatest need would be for organic matter and soluble plant food.

Genesee Fine Sandy Loam.

The surface of this soil is a mellow brown fine sandy loam averaging 10 inches in depth, and is underlain by light-brown or grayish-brown fine sandy loam slightly mottled in the lower depths with gray and brown. The substratum consists of alluvium ranging from clay to sands and gravel.

This type occurs as narrow strips along the Tippecanoe River

and some of the larger streams. The topography is level, but more or less cut up by old stream channels. Along Big and Spring Creeks this type is rather uneven in the surface, and includes more or less Fox fine sandy loam. Along the upper courses of Moots, Spring, Big, Honey, and Monon Creeks the bottoms become black enough to be classed with the Wabash series, but on account of their small extent are grouped with the Clyde soils, which they resemble and into which they grade.

The bottoms are subject to overflow at the time of the spring freshets or after very heavy rains. At other times the drainage is naturally good because of proximity to streams and fairly porous substratum.

The Genesee fine sandy loam is very inextensive in White County, and of little importance in the general scheme of farming. Probably 25 per cent. of the type still bears the original growth of sycamores, willows, water maples, elm, pawpaws, hackberries, oaks, etc., and the remainder is used for crops.

The principal use of this type is for corn, oats, and pasturage.

The yields of corn and oats may vary from 20 to 60 bushels, and probably average 30 bushels per acre.

This soil is recognized to be a good corn soil, and is planted to that crop most of the time. Careful cultivation is needed to keep the fields free from weeds, as they are seeded by the frequent overflows. Fertilizers are rarely used.

The value of this land depends on the character of the adjoining soils and location in reference to markets. One hundred dollars per acre would buy most of it.

The soil is quite sweet, and might be used for clover in the better-drained areas. Thorough cultivation and careful seed selection increase corn yields.

Fox Fine Sandy Loam.

The soil of the Fox fine sandy loam is a brown to light-brown, fine to medium sandy loam. At about 10 inches it grades into light-brown fine sandy loam, or loam which passes into light grayish-brown gravelly loam or earthy gravel. The substratum consists of loose gravel beds, with stones ranging in size up to several inches in diameter. A large share of the gravel is derived from limestone. The lower subsoil effervesces with acid.

This type occurs in a terrace position along the Tippecanoe River as far north as Wright's Ford, and along Moots Creek, and

in a few small areas along the other large creeks. It is above overflow, and is sometimes 30 or 40 feet above the streams.

The topography is typically flat, but some areas slope decidedly from the uplands to the first bottoms, and are of uneven surface, due to erosion.

The surface drainage is complete, and the gravelly substratum makes this land rather droughty.

Possibly 15 to 25 per cent. is in pasture and woods.

Corn, oats, and wheat are the main crops, and all farm animals graze on the pasture on this soil.

The average yields of corn and oats are 25 to 30 bushels, and wheat is about 12 to 15 bushels per acre. In wet seasons these yields may be much more.

Fox fine sandy loam is handled and fertilized much like the associated Miami soils.

This soil sells for about $100 to $125 per acre, except where it has a high value because of the gravel pits located on it.

This soil would be benefited by more thorough cultivation to conserve moisture, and by growth of legumes for the nitrogen and organic matter they will add to the soil.

Muck.

This soil is a black muck composed almost wholly of organic matter from 12 inches to 3 feet in depth. In the deeper phases it is underlain by brown fibrous peat or an ashy feeling loam where the muck beds have been burned out. The shallow muck is underlain by brownish and grayish fine sands, which also compose the substratum.

This soil is found in small areas throughout the sandy portion of the county, and in two or three large areas in Monon township. A few small spots are located in the southeastern part of the county.

The topography of muck is flat and depressed below the surrounding land. This type was formed from the heavy growth of marsh grasses, flags, rushes, and mosses in the old ponds and marshes, and was naturally covered with water most or all of the year. It sometimes has a sparse growth of aspens and willows. All but a few areas are now ditched and tiled, so that farm crops can be raised.

Muck is not extensive enough to play an important part in the agriculture of White County. Probably 75 per cent of it

is used for the production of cereals and the remainder for marsh hay and pasturage.

Corn and then oats are the important crops grown on muck. It is somewhat used by cattlemen for pasture and hay.

In one or two instances onions have been grown on muck in White County, with moderate success.

The average yields of corn and oats on muck are about 35 or 40 bushels per acre, with the usual fertilization.

Muck is handled like any of the black lands, and is often put in corn for several years in succession. Many areas become unproductive after several crops, and this land is usually treated with kainit, muriate or sulphate of potash or some mixed goods containing potash and phosphoric acid, with good results. This material is applied at the rate of 100 pounds to 200 pounds per acre by means of fertilizer attachment on a corn planter.

The value of muck varies from very little to over $150 per acre, according to drainage, distance from town, and the nature of the other soils on the farm.

Muck is adapted to a variety of special crops, as shown by the general practice on this type in northern Indiana. It is a first onion soil, and sometimes gives large returns from this crop. However, the crop yields and price per bushel are so underlain, and so much hand labor is involved that onion growing is a hazardous business. Mint growing is another special line of farming for muck, but there are no stills for the extraction of the oil in White County. Celery, hemp, sugar beets, and sunflower seed are often profitable crops on muck in other localities, and might be tried in White County if special knowledge and facilities were provided. Irish potatoes are a more practicable crop to be grown on muck in White County. Purdue recommends the application of 200 pounds acid phosphate and 200 pounds of sulphate of potash per acre for potatoes on this class of soil. Some muck is sweet and requires no lime, while other areas are sour, as shown by growths of huckleberries, dewberries, etc., and by acidity tests. Such land requires applications of ground limestone, and usually needs phosphoric acid even more than it does potash. The use of fertilizers not only increases yields, but improves the quality of corn wonderfully.

SUMMARY.

White County comprises an area of 507 square miles in northwestern Indiana.

It is a gently undulating plain lying 800 feet above sea level, with the narrow valleys of the Tippecanoe River and larger creeks cut 20 to 120 feet below the general elevation.

The northern half of the county is an old lake plain characterized by black, formerly marshy, sandy lands and light sand ridges. The southern half is a glacial plain with low moraines, and has both timbered and prairie lands.

The area is now completely drained by artificial outlets and tiling.

The inhabitants of the county were drawn from the eastern states, and a few from foreign countries, together with a recent influx from Illinois.

Monticello has a population of about 2,000, and is the county seat.

The county is very well improved in respect to schools, roads, drainage, telephones, farm buildings, etc.

The climate is temperate, though great and sudden variations occur. The growing season is nearly six months between frosts.

This area was first farmed by white men in the 20's. Timber lands were used before the prairie and marsh lands.

Since 1875 the predominant type of agriculture has been based on the production of corn and oats. Wheat and clover are important on the lighter-colored lands, and hog and cattle have been extensively fed by many farmers.

The average value of land for the county is $77 per acre.

The Miami soils of White County include the light-colored timbered lands of glacial origin, and are used for corn, oats, wheat clover, and livestock feeding.

The Bellefontaine series includes the "chocolate clay" lands, and correspond closely to the Miami soils.

The Carrington soils are deep black, with brown or mottled brown and gray subsoils. This land was originally prairie, and includes some of the best land in the county. The silt loam and its flat phase are the main types.

The Clyde series includes land which was originally marshy but is now well-drained. The soils are black and subsoils gray or gray mottled with brown. Textures range from loamy fine

sand to silty clay, but the fine sandy loam is the most extensive type.

Some muck is found in White County, and is a good corn soil when fertilized with potash.

Dunkirk fine sand is the flatter and better kind of deep light sandy land found in the northern half of White County.

Dunkirk fine sand—rolling phase—includes the deep droughty sand ridges of the old lake plain region.

The overflowed bottoms along the larger streams were mapped as Genesee fine sandy loam.

Second or nonoverflowed bottoms underlain by gravel beds were mapped as Fox fine sandy loam.

The recommendations for improvement of practice are based on two bulletins of the Indiana Experiment Station called "Unproductive Black Soils" and "Fertilizer Experiments on Clay and Loam Soils;" also on their acidity tests of soils all over the State. Some general points are based on information gained from talks with Purdue professors.

Soil Survey of Starke County, Indiana.

By E. J. Grimes, in Charge, and Wendell Barrett, of the Indiana Department of Geology, and T. M. Bushnell, of the U. S. Department of Agriculture.

Description of the Area.

Starke County, Indiana, is in the northwestern part of the state; it is one county south of Michigan, and two counties east of Illinois. It is bounded on the north by Laporte and St. Joseph Counties, on the east by Marshall County, on the south by Pulaski County, and on the west by Jasper and Laporte Counties. The northwestern boundary follows the Kankakee River. Roughly, it has the outline of a right angle truncated triangle. Its eastern border is 18 miles, and its southern border 24 miles in length. The county has a total area of 314 square miles, or 200,960 acres, including about 2,000 acres of water surface.

The surface of the county is predominantly flat and smooth, and characteristic of an old lake plain. The only pronounced irregularities are the sand ridges of dune-like hills, which are of common occurrence, and a weak morainic belt in the southeastern part.

The ridges roughly form three irregular belts extending in a general north and south direction; in no place are these ridges continuous, but they are frequently broken by smooth areas. The most prominent ridges are 30 to 40 feet high. The majority are less than 10 feet high, and many are only slightly elevated above the surface of the plain. The average width of the ridge belts is 1 to 2 miles.

One belt occurs along the eastern boundary of the county, extending from Eagle Lake north to St. Joseph County. This section embraces some prominent isolated hills and a rather continuous rolling area about Koontz Lake. Another belt, consisting of a series of long, disconnected ridges, extends from Ora northwestward to Knox. It roughly parallels the outer border of the morainic belt to the east. The third belt lies east of North Judson and reaches from the Pulaski County line north to the

Kankakee marsh. The surface is gently rolling, consisting of a series of low, irregular swells, or ridges.

The morainic belt occurs in North Bend Township Its most prominent feature is a high ridge east of Bass Lake. The plain to to the east of this is dominently level, varied occasionally by low mounds. In the southeastern corner of the county the gaps between the morainic undulations are filled with prominent sand ridges.

Throughout the remainder of the county, the monotonously level sand and muck areas are interrupted in only a few places by an isolated sand ridge or swell.

The drainage of the greater part of Starke County is into the Kankakee River. North Bend Township, however, and a small part of California Township are drained by the Tippecanoe River, which enters and leaves the county near the southeastern corner, forming a small loop.

The natural drainage was at one time through Yellow River, which flows through the center of the county, and Eagle Creek (Walker Ditch), Bogue River, and Pine Creek which flowed into the Kankakee. South of the Kankakee River for a distance of 20 miles there is not sufficient relief for the development of drainage ways, and the county at the time of its first settlement was a vast marsh. The drainage now is accomplished entirely by an extensive system of dredged ditches.

The average elevation of Starke County is about 700 feet above sea level. The Kankakee River has a fall of about 15 inches to the mile. A few years ago this stream would overflow its low banks and spread far out over the broad, level lands that bordered its channel, giving them the appearance of a vast morass. The river was dredged and straightened, and now flows freely through an artificial channel. The ditches generally have a fall about 6 to 12 inches per mile; farther back from the river there is sometimes a fall of 1 to 5 feet.

When the early missionaries, traders, and trappers came to this region, they found it in possession of the Pottawattomie Indians, a friendly tribe. By the treaty of 1832, these lands were ceded to the Government. The United States land survey was made in the years, 1833-1835. The first permanent settlement in the area now known as Starke County was made about 1840 near Ober, and was known as Osborn Settlement. The area was then a part of Marshall County. The adjoining counties were settled several years prior to the opening of Starke County.

The old Government land office was located at Winamac. The only bridge over the Kankakee River as late as 1850 was on the road leading from Walkerton to Laporte. There were only a few permanent settlers in the county as late as 1851. In the early fifties, however, a number of settlements were made, mainly north of Knox. The Monon Railroad was completed across the southwestern corner of the county in 1852, and the Nickel Plate and Pennsylvania Railroads were constructed in 1856. These railroads encouraged the settlement and development of the region.

Starke County was organized in 1852. When organized, it measured 18 miles square, but subsequently its boundaries were changed, the section northwest of the Kankakee River being annexed to Laporte County.

The population of the county has increased steadily. In 1860 it was reported as 2,195. The largest rain occurred in the decade 1890 to 1900. The early settlers were mainly from Ohio and southern and central Indiana, while the later settlers were mainly from Illinois and Iowa. In the 1910 census the population is given as 10,567. The entire population is reported as rural, only the population of towns of more than 2,500 inhabitants being classed by the census as urban. The population averages about 35 per square mile.

A large part of the farming population consists of Austrians, Scandinavians, Bohemians, Germans and Russians. The Austrians apparently pre-dominate.

Knox, the county seat, is located near the center of the county, on the Nickel Plate and the Chicago, Indiana & Southern Railroads. It has a population of about 1,800. It is 72 miles southeast of Chicago. The town has paved streets, electric lights and water works. A large pickle and canning factory is in operation at this place. North Judson is an important railroad town. A creamery is located here. The town has a population of about 1,500.

Hamlet is near the center of a rich farming section, and is a shipping point mainly for potatoes and onions. It has a population of about 600. San Pierre is an unincorporated town of about 300 inhabitants, in the southwestern corner of the county. Other towns of local importance are Grovertown, Ober and Ora. Davis, Alldine, Rye, Lena Park and Bass are small settlements and railroad station.

Starke County is fairly well supplied with good roads. In

1915, there was a total of 731 miles of roads, 303 miles of which were improved with gravel and stone. The gravel has largely been imported, as very little is found in the county. Many miles of road are built on dredge banks.

Several railroads afford adequate shipping facilities. The northern part of the county is crossed from east to west by the Pittsburg, Ft. Wayne & Chicago, the central part by the New York, Chicago & St. Louis (Nickel Plate), and the southern part by the Erie. The Chicago, Indiana & Southern extends from the extreme southwestern corner diagonally across the county through the northeastern corner. The Pan Handle division of the Pennsylvania System, the Chesapeake & Ohio, and the Michigan City division of the Monon crosses the southwestern corner of the county.

With two exceptions, the lakes of the county are small and of little importance. Bass Lake, 5 miles south of Knox, and Koontz Lake, in the northeastern corner, are popular summer resorts. The shores of these lakes are dotted with cottages and hotels.

Climate.

The climate of Starke County is healthful and fairly well suited to farming. The winters are rather long and cold, and as a rule there is considerable snow. There is no weather bureau station in this county, but the records of the station at Laporte, Laporte County, are fairly representative of local climatic conditions. The mean annual temperature is reported at Laporte as 49 degrees F. The mean temperature for the winter months, December, January and February, is 24.7 degrees F., and for the summer months, June, July and August, 71.2 degrees F. The mean temperature for the spring months is 47.6 degrees F., and for the fall months, 52.4 degrees F. The maximum temperature recorded is 108 degrees F., occurring in the month of July, while the minimum is -21 degrees F., recorded in February. Long periods of hot weather seldom occur, though occasionally for two to four days the temperature ranges from 95 to 100 degrees F. Zero weather seldom lasts for more than three to five days. It is usually accompanied by snow.

The mean annual precipitation is reported at the Laporte station as 35.6 inches. For the winter months the precipitation averages about 7.61 inches; this is largely in the form of snow. For the spring months, the average precipitation is 9.85 inches, for summer months, 9.92 inches, and for fall months, average

8.31 inches. In general, the rainfall is quite evenly distributed throughout the growing season, the greater part of it occurring in the spring and summer months. Crops seldom suffer from drought or from excessive rainfall. The total amount of rainfall for the driest year recorded is 26 inches, and for the wettest year, 45.76 inches. The average annual snowfall is reported as 49.2 inches, of which 40.9 inches is recorded for December, January and February.

The average date of the last killing frost in the spring is May 1, and of the first in the fall, October 5. This gives a normal growing season of 156 days, or a little over 5 months. The date of the latest killing frost recorded in the spring is May 21, and of the earliest in the fall, September 14.

The water supply of the county is obtained mainly from shallow wells. Water is ordinarily reached at depths ranging from 10 to 30 feet. Most of the wells are in sand. Mosquitoes are quite troublesome, on account of the large areas of standing water. Apparently, however, they are gradually disappearing as their breeding places are eliminated by drainage and cultivation.

The data in the following table are compiled from the records of the Weather Bureau station at Laporte:

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT LAPORTE, LAPORTE COUNTY.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	26.3	65	—12	2.48	1.40	3.09	13.0
January	25.1	63	—10	2.25	2.66	0.96	12.8
February	22.6	61	—21	2.88	3.24	1.85	15.1
Winter	24.7	65	—21	7.61	7.30	5.90	40.9
March	37.8	82	— 2	3.13	4.70	4.22	3.6
April	46.6	94	10	2.61	1.37	2.25	1.3
May	58.3	93	23	4.11	2.25	7.04	T.
Spring	47.6	94	— 2	9.85	8.32	13.51	4.9
June	68.5	103	36	3.30	1.25	8.68	0
July	73.7	108	45	3.40	0.94	5.01	0
August	71.4	101	40	3.22	3.04	2.75	0
Summer	71.2	108	36	9.92	5.23	16.44	0
September	64.3	103	29	3.17	3.10	5.26	0
October	53.2	92	8	2.36	1.22	1.38	T.
November	39.7	76	2	2.78	0.83	3.27	3.4
Fall	52.4	103	2	8.31	5.15	9.91	3.4
Year	49.0	108	—21	35.69	26.00	45.76	49.2

AGRICULTURE.

The interests of Starke County are primarily agricultural. The various soils are easily cultivated, and are well suited to the production of a wide range of crops. The great obstacle to agricultural development has been the poor drainage of all the county except the sand ridge areas. With the establishment of artificial drainage, mainly within the last 20 years, agriculture has increased

in importance; as drainage is provided, the area devoted to agriculture is extended.

The principal occupations of the inhabitants of the county prior to the last 12 to 20 years were hunting, spearing muskrats, fishing, cutting timber for railroad ties, picking huckleberries and cranberries, with which the county once abounded, and cutting marsh or prairie hay in the drier areas. This last industry was of considerable importance until only a few years ago.

Only the sand hills or higher lands were farmed, no thought being given to ever farming the swamps. The small tillable tracts were fenced and the cattle and hogs had free range. Corn, wheat, potatoes, buckwheat and sorghum were the chief crops grown. The first surplus product sold was potatoes. Very little grain was shipped prior to about 1895. Most of the corn used was shipped into the county. The early markets were Plymouth and Walkertown. The first wheat was sold at Michigan City.

The following table gives the acreage of each of the staple crops of the county as reported by the census for 1880, 1890, 1900 and 1910, by the Indiana Department of Statistics for 1913, and by the County Agricultural Agent School Census for 1915:

ACREAGE OF STAPLE CROPS.

Year.	Corn.	Wheat.	Oats.	Rye.	Potatoes.
1880	7,555	3,954	1,259	1,003	291
1890	7,828	3,097	3,367	2,386	674
1900	26,460	2,736	7,022	3,164	906
1910	28,435	5,191	7,373	3,519	2,147
1913	29,351	5,423	11,883	3,364	1,464
1915	21,304	8,722	9,626	3,173	2,218

In addition to the above staples, the 1910 census reports a total of almost 15,000 acres in hay and forage crops. Of this, 5,721 acres are reported in tame or cultivated grasses, consisting mainly of timothy, with 7,165 acres in wild, salt, or prairie grasses, and 1,319 acres in coarse forage. Grains are cut green from small acreage, and some clover, millet and alfalfa are grown.

Buckwheat was reported in 179 acres in the 1880 census, and later became an important crop, the acreage increasing to 1,036 in 1899. In the 1910 census, however, it is reported on only 688 acres. Dry peas are reported on 462 acres in 1909, and some barley and beans are grown. In addition to potatoes, all other

vegetables are reported on 1,416 acres in the 1910 census. In the 1890 census about 10,500 apple trees and about 1,000 peach trees are reported. The 1900 census reports about 24,000 apple trees and barely 2,000 peach trees, and the 1910 census a total of 23,042 apple trees and almost 10,000 peach trees, with 6,583 grape vines. Berries are grown on a few acres.

The 1910 census reports 1,291 other cattle and 2,304 calves sold or slaughtered. A total of 8,863 hogs, and 389 sheep and goats are reported sold or slaughtered, with 395 horses and mules sold.

The following table gives the relative value of farm products, arranged by classes, according to the census of 1910:

Cereals	$584,241
Other grains and seeds	6,781
Hay and forage	98,922
Vegetables	149,978
Fruits and nuts	13,367
All other crops	33,968
Live stock and products:	
Animals sold and slaughtered	220,571
Dairy products, excluding home use	99,761
Poultry and eggs	107,028
Wool, mohair and goat hair	1,347
Total value	$1,316,064

About 15 to 20 per cent of the total area in cultivation is devoted to the production of corn. The average yield for all types of soil is something less than 30 bushels per acre. The general increase in the corn acreage is due in part to the reclamation of large areas of the Clyde soils, which are favored for corn, and to the fact that it is the most profitable of the grain crops. Commonly a large part of the corn fails to mature properly in unfavorable years. It is practically all drilled in, in order to insure a stand. In places the sprouting corn is seriously injured by the striped gopher. Most of the corn is husked by hand, although an increasing acreage is used for ensilage each year. About one-half the crop is sold; the remainder is used on the farm. The average farmer considers it more profitable to use the corn for feed.

Wheat is considered a profitable crop. Yields range from about 25 to 35 bushels per acre. Oats are uncertain. The average yield is about equal that of wheat. Both crops cost about the same for production, but the selling price of wheat is generally

almost twice that of oats. At the time for seeding oats, the farmer is busy preparing the land for corn. Wheat, on the other hand, is planted and harvested at times when the farmers are not busy with the corn crop. Under these conditions, oats are often grown at a loss. This crop is sometimes cut green and used for hay.

Rye is a crop of some importance, mainly on the light sandy soils. Generally it is sown at some convenient time in the fall on the oats and wheat stubble, at the rate of 1 1-4 bushels to the acre. Where grown for soil improvement, it is pastured in the fall and early spring and plowed under, the land then being used for corn or cowpeas. The thrashed grain is largely marketed. Rye is sometimes cut green for hay.

Throughout the history of the county, potatoes have been an important crop. Starke County ranks third or fourth in the state in total production of potatoes. In 1915 there were 2,218 acres reported. They are grown either as a truck crop or in a system of mixed farming. The better quality of potatoes are grown on the Clyde soils, but larger yields are obtained in areas of Muck. Most of the growers have 30 to 35 acre tracts; occasionally larger fields are grown. The average farmer has from 1 to 10 acres in potatoes. The yields range from 75 to 250 bushels per acre. All the potatoes, except those kept for home consumption and for seed, are marketed. They sell for 25 to 75 cents per bushel.

Hay is of considerable importance in the agriculture of Starke County. Besides the wild or marsh hay which has been an important source of income since the earliest settlement of the county, timothy, clover, timothy and clover mixed, cowpeas, alfalfa and millet are grown. Clover has never been a very important crop. It is confined mainly to the Griffin and Miami soils, although it is grown to a small extent on the better drained Clyde soils. Alfalfa is grown successfully in a small way on the well-drained soils.

Buckwheat is said to be a fairly profitable crop, and may be grown on any type of soil, but does best on the Clyde soils or Muck. It is used only where the land can not be brought into condition for corn. Like oats, it is not fertilized. The average yield is 15 to 20 bushels per acre.

Cowpeas were introduced about 8 years ago, and are extensively grown, mainly in Washington, Oregon and Center Townships. During the last three years, the acreage has been doubling. In 1912, 797 acres, in 1913, 2,393 acres, and in 1915, 6,856 acres are

reported. This crop does well on the Plainfield fine sand. The yield ranges from 8 to 15 bushels per acre. The cowpea seed is all marketed, except the damaged or cracked grain, which is fed to chickens or hogs. In 1915 the average yield was only about 3 to 4 bushels per acre. The peas lodged and were badly damaged by cold, wet weather. Cowpea hay sells for $8 to $10 per ton; the thrashed hay sells for $4 to $6 per ton. The price received for the seed ranges from $1.40 to $2.50 per bushel. A small area is in soy beans; perhaps 100 acres were devoted to this crop in 1915. They are grown like cowpeas, and yield from 12 to 20 bushels per acre. They require inoculation. Vetch has been grown, either with rye or alone, but it is not popular with the farmers.

Onion growing started about 12 years ago, and since 1910 the industry has reached relatively large proportions. Starke County ranks first in the state in the production of onions. In 1912, 1,526 acres were reported in onions, with a production of 457,485 bushels. The low prices received in 1912 served to discourage many growers, and caused a number to discontinue the business. In 1913 only about 800 acres were devoted to onions. In 1915, however, there were about 2,000 acres. While the prices are subject to wide fluctuations, those who have remained in the business continuously have made a good margin of profit. There are three large onion storage houses at Knox one each at Hamlet, North Judson and Rye, and a few small individual storage houses at other places.

Peppermint was introduced about 10 years ago, and is receiving considerable attention. In the last two years the acreage has doubled. In 1915 about 1,000 acres were devoted to peppermint, with 370 acres on one farm. The price of the oil varies considerably, but the industry is profitable to those who remain in the business for any length of time.

Cucumbers are grown on several types of soils. Pickling sizes sell for 75 cents to $1 per bushel. Most farmers grow from 1 to 4 acres. Harvesting begins about August 1 and continues until frost. About 800 acres of cucumbers were grown in 1915, but the crop is not grown so extensively as formerly, because of the labor required in picking. There is a pickle factory at Knox, and salting stations at Grovertown, San Pierre and Alldine.

Sunflowers were introduced in the county in 1914. In 1915 about 300 acres were grown, mainly on Muck, with very promising results. Sugar beets were grown with success at one time on

the Clyde soils, but lack of a local market prevented the development of this industry.

Watermelons and cantaloupes can be successfully grown upon the light sands, especially with heavy applications of fertilizer.

A large number of vegetables, including celery, cabbage, tomatoes, turnips and peas, do well, but are grown only for home use or to supply the local market.

Peaches and apples are grown successfully on the Plainfield and Miami soils. Farm orchards generally receive little attention, and there are only two or three commercial orchards in the county. Small fruits, according to the census of 1910, are grown on only about 35 acres. Blueberries and dewberries grow wild throughout the county.

A considerable number of cattle are fed in the county. It is generally recognized that live stock is needed to maintain the productiveness of the soils. This is a stock feeding rather than a stock raising section.

The stockers are purchased from Chicago, fattened, and marketed at the same place. There is very little purebred stock within the county. Scrub or grade cattle are used almost entirely. Dairying is practiced more extensively than stock feeding. The average farmer keeps from 4 to 6 milk cows. The milk and cream are sold at North Judson or shipped to Plymouth and Chicago.

Hog raising receives some attention, but the extension of this industry offers excellent opportunities. It is profitable where carried on in conjunction with dairying, and large quantities of concentrated feed are produced on most farms in the form of cowpeas and soy beans. A number of farmers are engaged in poultry production. The climate, soils, and crops favor a greater development of the poultry industry. Considerable feed for live stock is purchased from outside the county. The census of 1910 reports an expenditure of $41,468 for feed.

In the agricultural development of the county, considerable recognition has been given to the adaptation of various soils to particular crops. The corn crop is confined very largely to the black soils of the Clyde series and to the Griffin loam, which is a very productive alluvial type. Corn is grown to some extent on the Plainfield fine sand, but the yields are light and the crops on this soil is being displaced by cowpeas. Corn is also grown on the shallower areas of Muck with fair to good results, but frosts are troublesome and two or more successive plantings are not advisable unless applications of potash salts are made. Wheat and

oats are grown chiefly and give best results on the Griffin loam, the Clyde soils, and the Miami fine sandy loam. Only fair yields of these crops are secured on the Plainfield fine sand, and on Muck, the yields are rather uncertain. Rye and cowpeas are confined almost entirely to the Plainfield fine sand, potatoes to the Clyde soils and Muck, and onions and peppermint to Muck and the mucky areas of the Clyde soils.

(Note to Inspector.—*Methods* of producing staple crops of county, *Corn, wheat, oats, and rye,* should be discussed briefly.)

Potatoes are planted in rows, 3 to 3 1-2 feet apart, after danger of frost is past. The Early Ohio and Rural New Yorker are the most popular varieties. A few growers treat the seed for scab. Potatoes are given three or four cultivations. Most of the growers use acreage applications of about 200 pounds of muriate of potash and occasionally 300 pounds of acid phosphate. Many farmers use the same fertilizers for onions, except that the applications are about one-half as heavy. On the better Muck farms, the potato industry is highly developed. Planting and digging are done by machinery. The ground is prepared with plow and rollers pulled by oil tractors. Potatoes are considered a profitable crop. They are grown in some cases in rotation with onions.

Cowpeas are seeded as soon as the ground warms up, usually about May 1 to 20, the peas being drilled in with a corn planter, in rows 3 to 3 1-2 feet apart Where grown for seed, one-half bushel per acre is used, while 1 1-2 bushels per acre are broadcasted where intended for hay. Three or four shallow cultivations are given. The vines are cut with specially devised implements that are intended to sever the vine near the ground, but oftener the plant is uprooted. They are cut before there is danger of shattering, allowed to cure, and placed in small cocks or stacked. Harvesting for seed is done usually about September 1 to 15. While there may be some improvement on the land where the cowpeas are cut and thrashed and the straw is removed from the land, better results in the way of soil improvement are secured where the cowpeas are hogged off or the vines plowed under about the time the pods begin to form, or if harvested, where the crop is fed to live stock and the manure returned to the land. Cow peas are a valuable hay crop.

(Note to Inspector.—In one or two paragraphs here *methods* of growing buckwheat, soy beans, vetch, alfalfa and clover, and cucumbers should be mentioned.)

Onions are planted between the middle of April and the first of May. Muck land intended for onions is generally plowed in

the fall and allowed to freeze and settle during the winter. In the spring the ground is thoroughly worked until a good seed bed is obtained. Onions usually are grown on land that has been used for the same crop the preceding year. This is one of the few crops that give better results where grown continuously, unless the soil becomes infected. Four pounds of seed are used per acre. Most of the seed is secured from Ohio. The seed is sown with a garden drill, usually one inch deep and in rows 13 inches apart.

In most cases, onions are grown in fields of 1 to 5 acres; in some instances they are grown on 10 to 30 acres, and in one case on 90 acres. Onions fit well into the farm rotation, as the ground can be prepared the preceding year, and the crop planted in the spring earlier than the other farm crops. It is harvested earlier than corn, and before wheat planting time. The Red and Yellow Southport Globe are the varieties most commonly grown. Cultivation begins as soon as the rows can be followed. Hand cultivators and weeders are used, and wheel-hoe and hand weeding are done alternately until the onions start to bulb, usually about August 1. Commercial fertilizers for onions are in general use. Most growers use 150 to 200 pounds of muriate of potash per acre, and a large number also use 200 pounds of acid phosphate or basic slag with the potash. Some farmers use 500 to 700 pounds of a 10-10 mixed fertilizer. The fertilizer is broadcasted before seeding, and worked in. A few farmers apply nitrate of soda after the onions are up, but its use apparently is not profitable. The principal enemies of onion culture are thrips, onion maggot, blight and mildew. Young onions occasionally are destroyed by the drifting of the soil. Cold wet seasons also are injurious. Harvesting is done about the last week in August to the last of September. The onions are pulled and thrown into windows and allowed to cure, which requires from 7 to 10 days. Topping is done either by hand or machinery. After topping, the onions are allowed to further cure in crates or in cribs built for this purpose. They are then either marketed or placed in winter storage. The onions sell for 25 cents to $1 per bushel. The cost of production averages about $75 per acre.

The land intended for peppermint, is cleaned by growing well-cultivated crops the year before, plowed, leveled and marked off in furrows 35 to 42 inches apart and 4 to 6 inches deep. The runners are dropped by hand, and the furrows are then filled in by a drag. Planting is usually done before May 1. Seventy-five to 100 pounds of muriate of potash per acre is broadcasted.

Harrowing is repeated at frequent intervals until the sprouts are too high to be further disturbed, after which corn cultivators are used between the rows until July, when the tops and runners interfere. Hand weeding is also practiced from the first appearance of the sprouts. The peppermint is cut with a mower and allowed to cure like clover hay. It is then raked in windows and hauled to the stills. Harvesting begins with the old plantings about the middle of July, and for the younger plantings about a month later. The plants after distilling are dried and used for hay, averaging 1 to 1 1-2 tons per acre. This is considered a good winter roughage for live stock, and sells for $4 to $10 per ton. After the crop has been harvested, the second growth is plowed under before cold weather. Before the growth starts the following spring, the soil is loosened with spike-tooth harrows. Cultivation is continued until the sprouts are tool tall to be gone over without injury. The plantings last from 3 to 12 years.

The roots required to plant an acre of peppermint are secured at a cost of about $10. The yield of peppermint oil ranges from 15 to 60 pounds; the young mint averages 40 pounds per acre, and old plantings about 30 pounds. The total cost of production is about $37 per acre. Peppermint oil sells for 75 cents to $5 per pound; $2.50 is considered a good price. A number of distilleries are in operation in the mint growing section. Oil is distilled for 25 cents per pound for some of the smaller growers.

In the last few years, there has been a rapid increase in the use of commercial fertilizers. Large quantities of potash and mixed fertilizer are used, and there is a decided tendency toward the use of raw materials and home mixing. Potash fertilizers are needed in the type of farming that prevails in this county. A large quantity of limestone is being used. Limestone now costs $1.10 to $1.50 per ton, delivered to various points in the county. Most of the soils of the county are in need of lime, especially the Clyde and Plainfield soils. Muck is not generally considered to be benefitted by lime. Phosphatic fertilizers are needed and are widely used in both truck and general farming. Light applications are made on all the corn lands. The 1910 census reports an expenditure of $11,467 for fertilizers, as compared with $1,100 reported for the county in 1900.

Satisfactory farm labor is rather scarce. Owing to the large number of special crops grown, there is a great demand for labor at certain seasons. Onions and peppermint require considerable hand work. Boys and girls are mainly used for this work, and

receive $1 to $1.50 per day. Men are paid $1.50 to $2.00 per day for work in the onion fields. Ordinary farm labor is paid about $20 per month and board, and extra help is hired at an average rate of about $2 per day. A large number of women perform light farm labor. The 1910 census reports an expenditure of $83,175 in the county for labor. In the 1900 census an expenditure of $48,070 for labor is reported.

According to the 1910 census, there are 961 farms in the county with an average size of 114.3 acres. In 1913 a total of 1,552 farms of 5 acres or more is reported. In the system of mixed farming that prevails in this county, the farms are necessarily small, and there are many small holdings, with but few large farms. The only large estates are in the undrained sections along the Kankakee River. The census reports about 81 per cent of the county in farms, and of the farm lands, 67 per cent is reported improved.

As compared with many counties of the state, there is little tenant farming. The census of 1910 reports about 30 per cent of the farms operated by tenants, and practically all the remainder by the owners. Land is generally rented on the share basis. The tenant furnishes the work stock, has a half interest in the other live stock, supplies working capital, and clears and fences the land, cuts weeds, etc. The owner receives one-half of the proceeds from the crops produced.

Land values vary considerably, depending mainly on the character of the soil. In the past 5 or 6 years, land prices have rapidly advanced. Twenty years ago land was selling for $5 to $6 per acre. Improved land in areas of the Plainfield fine sand now sells for $50 to $75 an acre. Land of the Clyde fine sandy loam is valued at $90 to $140 per acre. Well drained Muck lands sell for $75 to $100, and the improved Muck farms are held for $150 per acre. The average value of farm land in this county is reported in the 1910 census as $40.64 per acre.

There has been considerable speculation in real estate in recent years, and many farms change hands frequently. Immigrants from Chicago, mainly foreign born, acquire farms in the county, but in most cases, owing to lack of experience or of capital they are unsuccessful in farming, and after one to five years give up the land to their creditors. Under this condition, inferior land often sells for high prices. New settlers usually cannot farm the light sandy Plainfield soil or the shallow areas of the

Clyde fine sand with profit, and after a short time give up their farms.

Improvements in different parts of the county vary widely. Davis and Oregon Townships are highly developed to agriculture, while in Washington, California and Railroad Townships the farmers apparently are less prosperous.

The agriculture of the county is rapidly improving, but it cannot be said to be anywhere near its highest development. The extension of agriculture is largely dependent upon the extension and improvement of drainage. The future of Starke County seems to lie in the intense development of its vast areas of Muck land for both special and mixed farming.

SOILS.

Starke County lies within the glaciated region of the United States. During the latter part of the glacial period, and for some time following, the formerly glaciated region from a point north of the Kankakee River southward seems to have been occupied by a rather extensive lake or marsh. It is said that this "lake" apparently consisted not of any general body of water but of small, shallow-marsh areas, but very different from those of the present Kankakee marsh.

Leverett, Monograph 53, *U. S. Geol. Survey.*

The great accumulation of sand is thought to have been derived from the adjacent ice lobes—the Lake Michigan ice lobe bordering the area on the north, and the Erie-Saginaw lobe to the east. It is thought that much of the sand was brought into the great Kankakee basin by glacial streams that discharged through the St. Joseph River during the melting of the ice to the north. Throughout this area the sand is uniformly fine, and appears to have been deposited by streams with rather sluggish currents.

The underlying deposits consist of grayish-blue calcareous bowlder clay, with many abrupt changes from clay to sand. The depth of the sandy mantle is unknown, but perhaps averages over 40 feet. Bedrock everywhere is deeply buried. From near San Pierre to the Kankakee River the depth to rock is only 40 to 50 feet; elsewhere it ranges from 100 to over 200 feet.

There is an area extending eastward from Bass Lake into Marshall County in which the material was laid down by the ice as a moraine. Its elevation is perhaps well above the level of the

ancient lake, plain. The area is marked by patches of bowlder-strewn gravelly clay or till. This moraine is possibly a part of the great Maxinkuckee moraine which is encountered in Marshall County and which belongs to the Saginaw lobe of the ice sheet.

The sandy water-laid deposits, together with a small area of ice-laid material, constitute the parent material of the soils of the county. While the lake was in existence it received material carried into it by various streams. The coarser particles were laid down as delta deposits near the mouth of the streams, or thrown up by the waves as beeches, islands, or sand bars along the shores. The finer particles were carried into the deeper, more quiet portions, and deposited as layers of silt and clay.

When the lake finally drained away westward, the same or other agencies of deposition became more active than before. Some of the material was further assorted and drifted by the wind. Much of the old plain remained swampy, favoring the accumulation of large quantities of vegetable matter. The lacustrine material has been weathered only to a slight extent. This large amount of carbonaceous material present and the consequent dark color constitute the most distinctive characteristics of the soils of this region. The higher lying areas of water-deposited sand as well as the more pronounced knolls and ridges resulting from wind action have good to excessive drainage and only a low content of organic matter.

The ice-laid material, because of its topography, has accumulated but little organic matter. The soils are gray to very light brown. The subsoil and till are calcerous.

The dark soils as a rule are not heavily forested. The early settlers found them treeless, or in what is known as "wet prairie." Little, if any, of the county had reached the dry prairie stage.

On account of the very small extent of valleys caused by erosion on this plain, the alluvial soils are not typically nor extensively developed. The alluvium appears to have been deposited directly on the old sand plain, as the material is underlain at about 3 feet by the lacustrine deposits. The source of the alluvium was the fill plain that forms the eastern limit of the ancient lake.

The soils of Starke County are uniformly fine textured, and the structure of both soil and subsoil is rather light and open, but they are not generally doughty or leachy, owing to the relatively high water table.

The dark-gray and black soils are classed with the Clyde and

Newton series, the light colored soils from water-deposited material with the Plainfield series, and the light colored till soils with the Coloma and Miami series. The alluvial soils are classed with the Griffin series. Muck is one of the extensive and important soils of the county. In addition to Muck, a miscellaneous classification, nine distinct soil types are recognized in Starke County. These represent six series.

The Clyde series is characterized by dark brown to black surface soils and gray, drab or mottled gray and yellowish subsoils, the dark color of the surface soils being due to the high percentage of organic matter resulting from the decay of plants under swampy conditions. The topography is level and the soils are naturally poorly drained, but when reclaimed they are highly productive and valuable for corn, grass, sugar beets, cabbage and onions. Three types, the fine sand, fine sandy loam, and loam, are recognized in Starke County. The Clyde soils are extensive, and dominate the agriculture of this county.

The Newton soils are intermediate between the Clyde series on the one hand and the Plainfield or Dunkirk series on the other. The surface soil is dark brownish gray, with a yellow to yellow and gray mottled subsoil of similar to somewhat heavier texture. The topography is flat to slightly undulating, and the natural drainage is poor.

The Plainfield series includes the light colored well-drained soils derived from water-deposited material. The surface soils range from brown to gray in color, and the subsoil from light brown to yellowish. The topography is level to undulating and ridgy. One type, the fine sand, is mapped, and is one of the most extensive soils in Starke County.

The Coloma series includes brownish gray to brown surface soils with a brownish yellow subsoil, which is not heavier than the soils in texture and is non-calcareous to a depth of 3 feet or more. The topography ranges from undulating to rolling, and good natural drainage prevails. The soil-forming material is till, derived largely from sandstone and crystalline rocks. The chief difference between the Miami and Coloma series is in the subsoil. Only the fine sand member of the Coloma series is mapped in Starke County, and this type is of very small extent and is unimportant agriculturally.

The soils of the Miami series are brown, light brown, or brownish gray, and are underlain by yellowish brown, heavier textured subsoils, which are distinctly calcareous below a depth

of 2 to 3 feet. These soils are undulating to gently rolling, and have good natural drainage. The series is represented by a single type in this county, the Miami fine sandy loam. The soils are in the main derived through weathering, from glacial till of a generally calcareous nature.

The soils of the Griffin series are brown to dark brown. The subsoil is mottled gray, yellow, and rusty brown. These soils are alluvial in origin, and are developed in the first bottoms of streams. They are subject to overflow. When properly drained they are well suited to corn and grass. In this county, two types are mapped, the Griffin fine sandy loam and loam.

The name and actual and relative extent of each soil type mapped in Starke County is given in the following table:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Plainfield fine sand	42,752	31.0	Clyde loam	7,104	3.6
Rolling phase	18,240		Griffin loam	6,464	3.3
Clyde fine sand	34,240	17.4	Coloma fine sand	4,416	2.2
Clyde fine sandy loam	33,792	17.1	Miami fine sandy loam	3,136	1.6
Muck	28,992	16.7	Griffin fine sandy loam	2,816	1.4
Shallow phase	3,136				
Sandy phase	768				
Newton fine sand	11,264	5.7	Total	197,120	.....

Clyde Fine Sand.

The surface soil of the Clyde fine sand consists of a black loamy fine sand, to an average depth of 9 inches, the depth ranging however, from 8 to 20 inches. It contains large quantities of organic matter. Where the drainage has been very poor, the organic matter content is so high that the soil is more or less mucky, but in the better drained areas the percentage is proportionately lower, in some cases being so small that the soil is hardly dark enough to be mapped as Clyde. The organic matter is responsible for the loamy texture; in most cases it consists of black, well decomposed, carbanaceous material, but in some areas the vegetable fibres remain.

The subsoil is quite variable. Usually it is a brown or grayish brown fine sand or loamy fine sand in the upper 8 to 12 inches, underlain by gray fine sand, sometimes mottled with yellow or

highly stained with iron. In places the subsoil is incoherent to a depth of 3 feet or more, but generally it is sticky. In other places, the upper subsoil is noticeably heavier than the surface soil. Usually the top layers contain a very small quantity of clay. Invariably below about 30 inches, the material is a compact or water-logged fine sand. In only a few instances is gravel present in the subsoil.

The substratum is a gray fine sand, extending to undetermined depths. It usually is highly streaked or stained with yellow from iron. The material excavated from drainage ditches contains some coarse gravel and rock fragments. After exposure, it is light gray and quite compact.

Where the Clyde fine sand occupies open glades, hay marshes or "oak openings," the surface 9 to 15 inches is a dark brown or black fine loamy sand, underlain by grayish compact fine sand. The water table is encountered at about 20 inches.

The Clyde fine sand is the most expensive type in Starke County (?), and is found in all sections. Its greatest development is in California Township. This type is spoken of locally as "black sand" or "black sandy soil." It is not popularly separated from the Clyde fine sandy loam. For agriculture it is considered somewhat less valuable than the Clyde fine sandy loam, but more valuable than the Plainfield fine sand.

The topography is characteristic of an old lake plain, being level to very gently undulating. The natural drainage is poor; the slope usually is so slight that water stands in places for long periods after rains. In general, the surface is so flat that large dredge ditches are necessary to drain the type properly. Artificial drainage has been provided for nearly all of this soil. There are a few small ponds or swampy depressions. The undrained areas are mainly used as hay marshes. The water table over a considerable part of the type lies within 3 feet of the surface. The soil is easily drained because of its open, porous nature, and where tile is installed it is not necessary to place the drains very close together.

A large part of this type originally was forested, mainly with swamp pine, oak, and red oak, with a sprinkling of quaking aspen, birch, and elder in the lower situations. The open glades or hay marshes are broken by low sand ridges covered with white oak; these places are known as wet prairies, or "oak openings." The thick growth of sedges and grasses are cut for hay or used for pasturage. Land that has been cleared or burned over and

allowed to revert to its natural condition is occupied by an almost impenetrable growth of quaking aspen.

The Clyde fine sand is used for both general and mixed farming, and a large part of the type is under cultivation. Corn, wheat, oats, hay and potatoes are the principal crops grown. Corn yields about 20 to 40 bushels per acre. Wheat does fairly well, but not so well as on the fine sandy loam. Oats average less than 25 bushels per acre. This is an excellent soil for potatoes and yields of 125 to 200 bushels per acre are obtained. Some cucumbers are grown on this type, and do well in years of low rainfall, but wilt and blight are considered more troublesome on this type than on the Plainfield fine sand. Buckwheat is an important crop, being grown on newly cleared areas, or when the corn fails. Cowpeas are sometimes grown, but with little success, averaging about 5 to 10 bushels per acre. Clover is uncertain. Soy beans are grown in a few fields, and the results indicate that this is the legume best suited to this type.

Fertilizers high in potash are generally used on the Clyde fine sand, and are considered necessary for profitable yields of all crops. About 200 pounds per acre of muriate of potash is used as an initial application for corn and wheat, and the beneficial effects of this last for 3 to 5 years, after which 50 to 100 pounds per acre are used for each crop, or 150 pounds is applied every other year. The use of fertilizers containing 6 to 8 per cent phosphorus and 10 to 12 per cent potash, at the rate of 200 pounds per acre for corn and 300 pounds for wheat, is popular. For potatoes and other intensive crops from 500 to 1,000 pounds per per acre is used.

A large part of the Clyde fine sand is in an acid condition. Some limeston is applied, but its more extensive use is needed. Well improved areas of this type sell for $50 to $90 per acre.

Clyde Fine Sandy Loam.

The surface soil of the Clyde fine sandy loam is a black loamy fine sand or fine sandy loam. It ranges from 8 to 18 inches in depth with an average of about 12 inches. The soil contains a high percentage of mucky, organic matter, and to this is due the characteristic dull brown or black color. The subsoil is a brown or grayish brown fine sandy loam to sticky fine sand or fine sandy loam extending to a depth of 30 to 42 inches and underlain by a gray, loose find sand.

The greatest variation in this type is in the texture and color of the subsoil. In many areas the material is uniformly loamy and contains sufficient clay to make it sticky or coherent. A part of the type is underlain at 15 to 30 inches by a grayish or grayish brown fine sandy loam or fine sandy clay. Iron occurs quite frequently in the soil and subsoil of this type in layers or as concretions or irregular masses. Where the iron is present at or near the surface, it sometimes interferes with cultivation. As a rule the iron-bearing layer is found at depths of 10 to 20 inches. The ferruginous spots vary in size from a fraction of an acre to 5 or 6 acres. They are not large enough to be satisfactorily indicated on the soil map. The largest occurs in sections 27 and 34 T. 32, R. 3.

This type is extensively developed in the Kankakee and Tippecanoe valleys, and includes some of the best farm land of the county.

As mapped in Railroad Township, a large part of this type is a dark brown or black fine sandy loam, grading at 8 to 10 inches into a dark fine sandy loam or sandy clay loam, which extends to a depth of 15 to 20 inches. Usually this lower section is highly mottled with yellow and rusty stains. In places it gives way to a gray or drab heavy sandy clay, which also is usually mottled. Along the Jasper County line, the subsoil is bright yellow or buff colored, much like that of the Carrington series, and some gravel and a large number of bowlders are present.

In Davis Township and in Center Township, north of the Yellow River and west of Knox, the subsoil of this type is much heavier than the typical. The surface soil generally is a grayish brown to black fine sandy loam 8 to 12 inches deep, resting upon a grayish sandy loam or sandy clay loam, slightly mottled with yellowish brown or rusty spots. This material may vary to a drab or bluish clay loam or silty clay, but gives way to a gray sand in the lower part of the 3 foot section. In this location the type is closely associated with the Griffin soils, and it is difficult to draw sharp boundaries between the purely lacustrine deposits and the alluvium, as they occupy similar topographic positions.

In North Bend Township, the Clyde fine sandy loam is developed in the low-lying areas of the out lying weak morainic belt. Some gravel and bowlders are scattered over the surface. The subsoil is generally dark gray or brown and mottled with gray and yellow or iron stains. It may contain some sand and gravel. It is much heavier than the typical subsoil, approaching a heavy

loam to clay loam. Its impervious nature renders the drainage poor. As a whole, the type in this locality, sections 2, 11 and 14, T. 32, R. 1, apparently is less productive than the Clyde fine sandy loam as mapped in other parts of the county.

There is a variation of this type, occurring in the lower situations, which closely approaches the characteristics of Muck in the surface portion. This variation is encountered mainly along the Kankakee River.

The natural drainage of the Clyde fine sandy loam is very poor. At the time of the settlement of this county, nearly all the type was in a marshy condition, and the establishment of extensive systems of drainage was required to reclaim the land. The drainage has been greatly improved in recent years by the use of tile. Most of this type has been put under cultivation in the last 15 years; large areas in Davis Township have been cultivated only about 4 to 7 years. Many areas near the Kankakee River do not have sufficient fall to afford adequate drainage, and are in a swampy condition or are cultivated only in dry seasons. Most of this type was wet prairie land, little of it was ever forested.

The surface configuration varies from nearly level to very gently undulating. At some places along the banks of drainage ditches water-bearing gravel is encountered at 8 to 10 feet below the surface, but as a rule such material, if present, occurs at much greater depths.

This type is so closely associated with the Clyde fine sand that definite boundaries can not always be drawn. The higher content of clay in the subsoil insures good capillarity and enables this type to withstand drought better than the fine sand.

Corn is the most important crop grown on this soil, and yields of 60 to 70 bushels per acre frequently are obtained. The average yield is about 50 bushels. Oats do well except in wet seasons when they usually produce a heavy growth of straw and are likely to lodge. This type is considered the best wheat soil in the county, with the exception of the Griffin loam. The average yield is about 20 bushels, though as much as 35 to 40 bushels per acre are obtained. Dawsons Golden Chaff and Michigan Amber are the most popular varieties. The application of about 200 pounds of potash per acre is considered beneficial in stiffening the straw. The potatoes are an important crop on this soil. Acreage yields of 150 to 250 bushels of potatoes of good quality are obtained. Onion and peppermint are occasionally grown in the

mucky areas. Clover, timothy, and alfalfa are produced successfully.

Land of this type has an average value of about $100 per acre. In some cases it is sold for $60 to $125, but the best improved land is held for $135 to $150 per acre.

Where a legume is needed, soy beans should be grown; cowpeas do not do so well on this soil. Some areas of the Clyde fine sandy loam are slightly acid, but it is not so generally in need of lime as the Clyde fine sand. Potash salts are needed for best results. When a fertilizer is used, a mixture of 10 per cent each of phosphoric acid and potash is recommended.

Clyde Loam.

The Clyde loam consists of a black loam or heavy fine sandy loam 8 to 15 inches deep, underlain by a grayish or brownish mottled heavy loam or sandy clay. The mottlings are mainly iron stains, and are yellow, red or brownish red. In the heavier material they are very pronounced. At 30 to 36 inches a gray fine sand is encountered, and this extends to a depth of several feet.

In the areas of this type north of San Pierre the soil to a depth of 8 to 10 inches is a black fine sandy loam, underlain by gray, drab or brown sandy clay or fine sandy loam, highly mottled with yellow and red. Frequently at 20 to 30 inches there is a layer of yellow iron concretions or drab and yellow sandy clay, and below 30 inches a gray fine to coarse sand usually is encountered. Iron concretions and gravel frequently are present in the soil and subsoil. Large granite bowlders are abundant, but these have been generally removed from the cultivated fields.

A few areas are included with the Clyde loam that consists of distinctly heavier material. The area in sections 27 and 34, T. 33, R. 1, includes clay loam underlain by mottled drab or gray and yellow, plastic silty clay, generally grading into sand in the lower part of the soil section. This area formerly was subject to overflow. Other spots of clay loam are scattered through the type in Davis Township.

The largest area of the Clyde loam is in Davis Township, north of the Pennsylvania Railroad, along the Kankakee River. Another area is mapped in Railroad Township. Small scattered areas occur throughout the county.

The surface varies from flat or depressed to very slightly undulating. This type was wet or marshy before artificial drain-

age was provided; a part of it is swampy at the present time. The area south of English Lake is not thoroughly drained. The greater part of this type has been under cultivation within the last 4 to 6 years. The improvements are good.

Corn, wheat, oats and hay are the principal crops grown, and of these corn is the most important. The average yield of corn is about 60 bushels per acre. Yields of 70 to 80 bushels are common. As a rule wheat is not fertilized, and yields of 20 to 35 bushels per acre are obtained. Clover does well. Timothy makes a rank growth.

No fertilizers are used on this soil. Owing to the rather large percentage of organic matter present it granulates and breaks up into a mellow condition, and is easily kept in good tilth. Where handled too moist, it has a tendency to clod. This condition readily distinguishes it from the other members of the Clyde or Plainfield series.

Well-drained land of this type is held for $100 to $150 per acre.

Newton Fine Sand.

The surface soil of the Newton fine sand is a dark grayish brown to black fine sand or loamy fine sand. The subsoil is encountered at 9 to 20 inches, and generally consists of a brownish or grayish, incoherent fine sand, low in organic matter. This grades into a yellow or orange colored, loose fine sand. A gray fine sand is frequently encountered below 10 inches, extending to depths of several feet. Small quantities of clay are sometimes present in the lower part of the subsoil, as in the case of the Clyde fine sand.

The Newton fine sand is uniform in the rather shallow depth of the surface soil and the light color of the incoherent subsoil. The widest variation in this type occurs in sections 2 and 3, T. 33, R. 2, where the material to a depth of 8 to 12 inches is a brown fine sand. This grades into a grayish brown, loose fine sand, which at 14 to 20 inches is underlain by a yellow, incoherent fine sand. This sometimes passes into a bright yellow or highly iron stained sand.

The surface of this is generally smooth and depressed, and the type is naturally poorly drained. There are a number of sand hills or swells which are entirely surrounded by soil of this type. Large areas of this soil occur between sand ridges.

A part of the Newton fine sand is forested with a dense growth

of swamp pine and red and black oak; the undergrowth is mainly huckleberry. The open areas support a sparse growth of sedges, brake fern, dewberries, blueberries and pine weed. Usually there is an extensive growth of moss. In cultivated fields, dewberries, pine weed, and sorrel are troublesome. The type is frequently referred to as "dewberry land."

This soil occurs usually in areas of only a few acres, but there are a few large bodies. Perhaps less than 20 per cent of the type is cultivated. When first broken, this soil apparently is as productive as the Clyde soils, but much of it will not produce profitable crops without special treatment, even after thorough drainage and liberal manuring and fertilization. A large area of similar soil lies between LaCrosse and Wanatah, Indiana, and experiments which have been conducted by the Purdue Experiment Station for a number of years on a farm one mile east of Wanatah, have shown that the yields of crops can be materially increased by the application of 3 to 4 tons per acre of ground limestone with liberal applications of fertilizer rich in available phosphates and containing some potash. The soil was not found to be in need of nitrogen. In the case of corn, the yield was increased from 7 bushels per acre on untreated land to 60 bushels per acre on land which was limed and fertilized, although these results were obtained about 2 years after the limestone was applied.

This type should receive at least 3 tons per acre of ground limestone or marl, and a fertilizer containing 10 to 12 per cent phosphoric acid and 6 to 8 per cent potash should be used. About 200 pounds per acre should be drilled in the row for corn, and 300 to 400 pounds for wheat. With proper treatment this soil is adapted to the same crops as the Clyde fine sand. Soy beans do better than cowpeas, for the reason that they will tolerate more acidity.

Note—Bulletin 170, Ind. Exp. Station.

Plainfield Fine Sand.

The surface soil of the Plainfield fine sand is a brownish gray to light brown fine sand. It is 6 to 15 inches deep, with an average depth of 7 or 8 inches. The subsoil is a yellowish brown to yellow, incoherent fine sand, extending to a depth of more than 3 feet The surface soil is dark brown when moist; when dry, it has a grayish cast. In flat situations and the local depressions, the subsoil is bright yellow, iron stained or orange colored, or may be stained reddish with iron. In these areas, the surface soil is

generally gray and the upper part of the subsoil grayish yellow. Distinct mottlings are rarely found. In forested areas only 2 to 4 inches of the surface soil is dark colored, and the underlying material is yellowish brown. The substratum, which extends to great depths, is a gray or yellow incoherent sand.

The surface soil is generally free from coarse material, although scattered gravel is present, with occasional bowlders. An area in section 16, T. 32, R. 4, carries some gravel, and the soil in the region north of Grovertown to Koontz Lake contains more gravel than the typical. An area of this soil north of the Tippecanoe River in section 34, T. 32, R. 1, occurs as a terrace. The surface soil is a brownish gray sand to a depth of 8 to 9 inches, and the subsoil is a yellowish brown coarse or medium sand. Some coarse sand and gravel is distributed over the surface and throughout the soil and subsoil. The substratum is mainly gravel.

The Plainfield fine sand is an extensive soil in Starke County, and is widely distributed. The largest area is in Washington Township, north of Yellow River. Another large area is encountered at Rye, extending southward toward Albine and Lena Park. A large part of the type consists of gentle swells or island-like areas in the Clyde soils. The crests of many of the elevations are only 1 to 5 feet above the level of the surrounding darker land.

The surface, as a rule, is smooth and generally flat or level. The largest area with very flat surface is found about Oak Grove Church, in Washington Township. A portion of the type has a gently undulating or wavy topography, but never decidedly ridgy. However, a few smaller isolated areas occur as low ridges, seldom over 3 to 4 feet above the surrounding Clyde soils.

The natural drainage ranges from fair to good with little that is excessive, but not so pronounced as in the Plainfield fine sand, rolling phase. Consequently there is less leaching and the organic matter is retained longer.

About 60 per cent of the Plainfield fine sand is under cultivation. The remainder is covered with scrub, white, and black oak. A part of the forested area is in woodlots, and a part is used for grazing.

A mixed system of farming is employed on this type. The soil is rather light for general farming. The greater part of the type is used for cowpeas, rye and corn. Cowpeas do best, and a large and increasing acreage is devoted to their production. The crop is grown mainly for seed (?), and the yield is 8 to 15 bushels

with a maximum of about 20 bushels per acre. Corn is not considered profitable; it averages about 20 bushels to the acre. The crop matures well, and the quality is good. Wheat does fairly well, and average yields of about 15 bushels per acre are obtained. Rye is a very successful crop, yielding 10 to 20 bushels per acre. Timothy and clover are uncertain. Oats do not give satisfactory yields. Alfalfa, with proper preparation of the soil, does well. Vetch is grown to a small extent. Cucumbers constitute the principal truck crop. Where well manured, this is considered the best soil in the county for this crop, although it may suffer from drought in years of low rainfall.

Frequently severe windstorms in the spring or early summer months, before the ground is well covered by growing crops, destroy young vegetation. Corn, cowpeas, and potatoes planted in hills are often more severely injured in a few hours by these storms than by heavy frosts.

Owing to the open, porous nature of this soil and its thorough drainage, it warms up early in the spring, and is well suited to truck crops and garden vegetables. Strawberries, blackberries, peaches and grapes are grown to some extent. Watermelons and muskelons and potatoes are produced successfully.

Commercial fertilizers are in general use on this soil. Most of the manure produced on the farm is applied to this land. The soil shows marked response to the use of lime.

Improved land of the Plainfield fine sand sells for $5- to $75 per acre. Some areas sell for $35 to $50 per acre.

The Plainfield fine sand is primarily in need of vegetable matter and nitrogen, and should first be improved by growing and plowing under cowpeas, rye, etc., and by applying ground limestone and manure. The type is deficient in phosphoric acid and potash, and the use of fertilizers containing 10 to 12 per cent of phosphoric acid and 6 to 8 per cent potash is highly beneficial. Acreage applications of 200 to 300 pounds of a 10-5 fertilizer drilled in the row are recommended by the Indiana Experiment Station for corn and cowpeas, and 500 to 1,000 pounds of the same mixture for potatoes. Rotations used successfully in the improvement of this type are; (1) cowpeas followed by rye turned under for corn or potatoes, (2) cowpeas and potatoes in alternation, (3) rye followed by cowpeas turned under for corn.

Plainfield fine sand, rolling phase.—This soil consists of 6 to 15 inches of yellowish brown or light brown fine sand, underlain by yellowish brown to orange yellow fine sand. In general, the sub-

soil is lighter yellowish brown than the surface soil, and the color becomes lighter with depth. As a rule, the yellow gives way to orange, and in rare instances the material is reddish. In many places there is little or no change in color from the surface downward.

The soil and subsoil are very smooth in texture, and are comparatively free of stone, coarse grit, and gravel, with the possible exception of a few high ridges near Bass Lake and Ora, where scattered angular fragments of igneous rocks are sometimes present. This phase contains only a small percentage of organic matter, and is so loose and incoherent that it is easily drifted where not protected by vegetation. In forested areas, the surface material to a depth of 2 or 3 inches is grayish, and immediately underlain by golden yellow or orange colored material which may continue to depths of more than 3 feet.

The substratum is a pale buff or yellow, loose fine sand, composed largely of well rounded quartz, but a number of other minerals are present. The sand is uniformly fine.

The rolling phase of the Plainfield fine sand has a large total area, and is distributed throughout the county. The largest areas occur along the eastern boundary of the county, north of Eagle Lake. A large area is mapped east of North Judson, extending from the Pulaski County line north to the Kankakee marsh. The greatest ridge development occurs in a series, or broken chain of sand hills extending from Ora to Knox.

The topography varies from gently rolling to dune-like. The phase occurs as low ridges, rounded hills, and knobs from 4 to 40 feet in height. A large part of the phase has no distinct ridge development, consisting of a series of swells or undulations. The ridges usually have a general north and south trend. They are generally long and narrow, varying in breadth from 50 feet to one-fourth mile. The ridges invariably occur along the borders of sand or Muck flats. The tops of the ridges are well rounded, and the sides adjoining the flats are frequently abrupt while the opposite sides slope gradually to the plain. The east and north sides are more often abrupt. In places the ridges enclose Muck swamps or nearly level areas, which frequently are not so productive as the greater part of the phase, the soil being a shallow brown or black sand overgrown with dewberries and other acid tolerant plants. A part of the phase occupies small ridges surrounded by the Clyde fine sand or Muck. Often, however, there is a strip of the typical Plainfield fine sand between this

phase and the Clyde soils. As a rule, no sharp line of separation can be drawn between the rolling phase and the more undulating areas of the typical Plainfield fine sand, and small patches of the phase are included with the main type. The topography, combined with the open, porous nature of the subsoil, give the phase excessive drainage. In the central part of the east half of section 6, T. 32, R. 3, there is an extensive gravel pit within this phase.

About 35 per cent of this phase is under cultivation; the remainder is either used for pasture or is covered with a dense growth of scrub oak. Areas of a few square miles in which this phase is the predominating soil are largely under cultivation. The steeper ridges and small isolated knolls are not farmed and mainly support a growth of scrub black oak. The greater part of the phase can be safely cultivated, but the prominent ridges are not desirable farming land. Owing to the low water-holding capacity of the soil on the ridges, crops are subject to drought except in seasons of well distributed rainfall. In addition, the soil is often lacking in productiveness, and subject to drifting, which frequently causes injury to crops.

Cowpeas and rye are the principal crops grown on this phase. Rye produces an average of about 10 bushels per acre. Cowpeas are grown with good results in favorable years, averaging 8 to 15 bushels of seed, with maximum yields of about 20 bushels per acre, and 1 to 2 tons of hay after thrashing. Most of the crop is cut and thrashed. The yields of corn are light, averaging less than 20 bushels per acre. Wheat does fairly well, averaging about 15 bushels. Alfalfa is grown on a few acres, and does well. Clover is grown, with varying results. It is difficult to obtain a stand of grass on this type. A mixture of Redtop, sheep fescus and alsike has been grown experimentally with success. Sunflowers are being grown in an experimental way. There are a number of peach orchards on this type, and the fruit apparently does well.

Drifting is a serious problem in the cultivation of this soil. The incorporation of large quantities of organic matter, plowing at right angles to the prevailing direction of the wind, and trampling by stock, together with the use of limestone or marl will lessen the injury from this source. A wind-break of pines or other trees is highly beneficial. Another effective plan is to lay out in long, narrow fields the areas that are seriously affected by wind action, and have the fields used for cultivated crops alternate with fields in which early crops, such as rye and clover, are grown.

This phase can be rapidly and permanently improved by growing cowpeas either to be turned under or to be fed and the manure returned to the land. Many acres of the phase on sand hills and ridges, now lying idle, could be profitably used for cowpeas.

Coloma Fine Sand.

The Coloma fine sand is a browinsh gray or light brown fine sand or loamy fine sand to a depth of 8 to 15 inches. Some cherty gravel and occasionally small granitic bowlders occur on the surface. The subsoil generally is a yellowish brown fine sand. In places the color changes to light gray below a depth of about 2 feet. In many places the subsoil resembles that of the Plainfield fine sand, but usually there is a pale, pinkish tint in the material, which is not present in the Plainfield subsoil. The substratum is encountered at varying depths, and consists of gravelly and stony till. In most places it is not reached within the 3 foot section. In some places when this type adjoins areas of the Plainfield soil, the original character of the surface has apparently been modified by material being transported by wind from the surrounding land. In most places it is distinguished from the Plainfield by the generally gray surface soil and by the presence of gravel. The type as mapped includes a few areas of Miami fine sandy loam, where the bowlder till is encountered within the 3 foot section. These areas are too small to be indicated satisfactorily on the soil map. They are locally referred to as "clay spots," and are naturally more productive than the surrounding Coloma fine sand. They contain more stony material than the typical Coloma soil.

This type is confined to North Bend Township, with the exception of an area north of Eagle Lake. The best developed area occupies a morainic belt just east of Bass Lake, extending in a northeast-southwest direction. This belt is about 4 miles long and its average width is about 1 mile. The north half is a succession of billowy ridges rising well above the general level of the plain; the southern part is level to undulating, much like the surrounding country. The other areas of the type vary from level to gently undulating. The drainage is good to excessive. The only poorly drained areas occur in small depressions.

Over 90 per cent of this land is under cultivation and is devoted to general farming. A large part of this type is closely related to the Plainfield fine sand and is handled in about the same way.

Its average productiveness is above that of the Plainfield soil. Clover thrives on most of the type, indicating some limestone influences. All the Coloma fine sand originally was forested with oak, hickory and walnut.

This type is valued at $60 to $90 per acre.

Miami Fine Sandy Loam.

The soil of the Miami fine sandy loam is a grayish brown to light crown fine sandy loam from 8 to 18 inches deep, with an average of about 10 inches, underlain by a yellowish brown or brown, heavy or sticky sand clay loam. Varying quantities of gravel and stone are scattered over the surface and throughout the soil section.

The area of this type on the crest of the moraine just east of Bass Lake is a gray fine sandy loam from 8 to 12 inches deep, passing into yellowish brown fine sand. At 18 to 30 inches a yellowish brown clay loam is encountered. The substratum consists of yellow sandy clay till underlain by blue calcareous clay till.

In the area bordering Marshall County, the heavy, compact, brown or yellowish brown subsoil is encountered at 8 to 12 inches. In a few fields, the soil approaches a loam, and locally the surface soil in underlain by yellowish brown fine sand, which extends to depths of more than 3 feet. In such places, the gravel content is low.

This type occurs almost entirely in North Bend Township, and is best developed in an area along the Marshall County line. It occurs in a strip about 1 mile wide, extending from Martz (?) Lake northward to the Nickel Plate Railroad. Probably the most typical area occurs in sections 1 and 12, T. 32, R. 1. Another area is found on the summit of the moraine east of Bass Lake in sections 5, 8 and 17, T. 32, R. 1. The remainder of the type occurs mainly on the plain near these areas. It generally occupies low swells or mounds, or island-like areas surrounded by darker colored soils.

The surface is mainly level or gently undulating, except on the high moraine where, owing to its position on the crest of the moraine, the soil is subject to some washing. The greater part of the type has good natural drainage because of the favorable character of the substratum.

The Miami fine sandy loam is one of the strongest soils in the county; the subsoil is heavier than that of any other type. Prac-

tically all the type is under cultivation and devoted to general farming. The small forested area supports a growth of white and red oak. This was the first soil in the county to be farmed.

Corn does well, and yields of 50 to 60 bushels, with an average of about 40 bushels per acre, are reported, although 18 or 20 bushels per acre is considered a good average yield. Cowpeas have been grown with success, but soy beans do not do so well. Oats are grown to only a small extent. Clover and timothy are grown extensively and make a rank growth, probably because of the calcareous nature of the subsoil. The surface soil shows some acidity. Some difficulty has been experienced in securing a stand of clover in recent years. Acreage applications of 1 ton to 3 tons of marl or ground limestone have proven very beneficial. Alfalfa thrives on this soil, and good stands are easily obtained. Limed land produces 5 tons of alfalfa hay per acre, and unlimed land something less than 3 tons. There are a few good orchards on this soil. Apples and other fruits do particularly well on this type.

No commercial fertilizers are used. A marked increase in yields follows the application of manure, even in small quantities, or the plowing under of clover or timothy sod. Such treatment, accompanied by the use of lime, seems to be the most effective means of improving this soil.

The improvements of the Miami fine sandy loam are much above the average of the county. Very little of the land can be bought for less than $100 per acre.

Griffin Fine Sandy Loam.

The Griffin fine sandy loam is a brown to rather dark brown, mellow fine sandy loam or loamy fine sand, 6 to 12 inches deep, overlying a loose fine sand, which is highly stained with red, brown, gray or some combination of these colors; throughout most of the type, the subsoil is widely variable.

In some places west of Knox, the type consists of 7 to 8 inches of brown fine sand or fine sandy loam, grading into a white or gray and red, clean sand; this rests upon a dark brown, heavy fine sandy loam. Commonly the material throughout the 3 foot section is a gray or light colored, loose fine sand. The type includes small areas of the Griffin loam.

The Griffin fine sandy loam is not extensive in this county. It occurs as first bottoms along the Yellow River. Most of the

type is well drained. Only a small part of it is under cultivation; the remainder is forested or is used for pasture. Good yields of corn and wheat are obtained on this soil.

Griffin Loam.

The soil of the Griffin loam to a depth of 8 to 10 inches, is a dark brown loam to silty loam. The subsoil is a clay loam to silty clay loam. It is mottled deep brown and gray, and brown and red iron stains are common. Below 18 or 20 inches is grayish sandy clay loam, slightly mottled with red, brown, and dark gray, is encountered. This grades into gray or highly iron stained fine sand at depths of 2 feet or more. Small iron concretions are rather abundant on the surface and throughout the soil and subsoil. The soil is generally quite friable and easily cultivated. In some areas there is only a slight difference in color between the soil and subsoil.

This is the heaviest soil mapped in Starke County. Some spots, too small to be shown separately on the soil map, have a clay loam surface soil. There are also a few small areas, of about 2 to 4 acres, of the Griffin fine sandy loam.

The Griffin loam occupies the first bottoms along the Yellow and Kankakee Rivers. It occurs as a continuous strip along Yellow River, but its development along the Kankakee is irregular. Much of the land along Yellow River has been in cultivation since the dredging of the river, but the areas along the Kankakee is irregular. Much of the land along the Yellow River has been in cultivation since the dredging of the river, but the areas along the Kankakee River are forested. The boundaries between these areas and Marsh are marked by the tree line. All the type originally was heavily forested with elm, silver maple and oak.

The type has a nearly level topography, but the surface is very uneven, being dissected by many old stream channels. The natural drainage is good. This land, before the deepening and straightening of the river, was subject to frequent overflow.

The Griffin loam is one of the best soils in the county for the production of wheat, corn and hay. Wheat does particularly well. Average yields of 35 bushels per acre are common, with an occasional maximum production of 45 bushels. The growth of straw is very heavy, and the use of mineral fertilizer probably would be beneficial. Corn yields 50 to 70 bushels per acre. Clover does better on this soil than on any other type in the county, and a large acreage is grown. It is grown both for

hay and for seed. No commercial fertilizer is used on this soil. Some of the type is devoted to pasture. Blue grass does well.

Well improved areas of the Griffin loam sell for $100 to $150 per acre. Little of this land is for sale.

Muck.

Muck consists very largely of vegetable matter. The material is so far decomposed that no evidence of the original fibrous structure remains. It ranges from a soft, finely divided soil to a sandy muck or to black mud, depending upon the stage of decomposition and upon the amount of moisture present. The color ranges from dark chocolate brown to black, and the depth generally from a few inches to 12 or 15 feet. The greater part probably averages about 5 or 6 feet in depth, although in places the Muck is said to extend to much greater depths. The most extensive shallow areas of Muck is that northeast of Hamlet, along the county line, where the average depth is less than 2 feet. This region was formerly known as the "sinks".

Very often, below a depth of 18 inches to 3 feet, light bown Peat is encountered. Usually, however, there is no change inthe material with depth. Some sand, silt and clay has been washed or blown into the depressions during the formation of this material.

The material underlying practically all the Muck in Starke County is a gray or whitish fine sand. In spots, this sand is stained yellow by iron or black by vegetable matter. Occasionally small quantities of gravel are present in the sand. In places, the Muck is underlain by a grayish marl or gravelly marl, and in rare instances a drab silty clay is encountered under the shallow Muck.

The area mapped as Muck on the site of Manitou Lake, in sections 13, 24 and 25, T. 32, R. 1, comprises a good development of peat. It was drained by a dredged ditch to the west a few years ago. The depth of the deposit ranges from 8 to 20 feet. The material is not sufficiently decomposed to make good farm land. The north and south ends of the area are forested with tamarack, while the remainder is an open marsh.

In general, the Muck as mapped, includes many small patches of Peat and mucky Peat. Some of the large areas mapped as Muck south of North Judson very closely approach the character of Peat, particularly in sections 21, 27, 28, 31 and 32, T. 32, N. Range 3 W.

The areas now recognized as Muck or marsh lands were once shallow lakes or shallow marshes. They were mainly treeless, and when the county was first settled a part of them supported a growth of marsh hay. The marshes and lakes were at one time popular for fishing and hunting. Several areas in the eastern part of the county support a heavy growth of tamarack. In the early history of the county, many of the Muck areas were used as cranberry marshes.

Muck is very extensive in Starke County. There are many areas of 4 or 5 acres or less. A large number of areas of 100 to 200 acres are common, and many that are much more extensive, ranging from 600 acres to a few sections. The largest bodies are in Jackson, Oregon, North Bend and Wayne Townships. The Muck areas are well distributed over the county.

The surface is practically level. In some areas, it has a hummocky appearance, owing to the occurrence of small tufts of grass, which seldom exceed 12 inches in height. Sometimes the surface is interrupted by small sand islands, only a few feet above the level of the marsh.

It is only within the last few years that any thought has been given to the cultivation of these marshes. They produced marsh hay, which was cut by machine if dry enough, but if too wet for a mowing machine, the hay was cut by hand and "poled", that is, piled up on two long poles so that it could be carried by two men. In the last 15 years, a comprehensive system of drainage has been established. Most of the Muck areas have been freed of the surface water, and the water table has been lowered, and a large part is successfully farmed. These lands are rated as the most valuable of the general region.

Muck is used quite extensively for the production of onions, peppermint and potatoes, and to a smaller extent for corn, oats and wheat. The average yield of onions under favorable conditions is about 300 bushels per acre. In 1915 the average yield was about 150 bushels. In many cases yields of 500 to 600 bushels are obtained.

Potatoes are grown to a considerable extent, and yield from 100 to 250 bushels per acre. The quality is somewhat below that of the potatoes grown on the Clyde soils. Cabbage, celery and other vegetables are grown to a very small extent, mainly in tracts of 1 to 4 acres. Sunflowers are a new crop on this soil; about 300 acres were grown in 1915. The yields ranges from 500 to 1,000 pounds of seed per acre.

Corn and oats yield about 40 bushels per acre. In growing corn, about 200 pounds per acre of muriate of potash is broadcasted the first year and about 100 pounds each year afterward. Many farmers are unsuccessful in growing oats on Muck, usually because they sow too early and do not plant deep enough. Good results are reported where the crop is drilled in about 2 inches deep on well compacted soil. Good wheat yields are obtained where the Muck does not exceed 3 feet in depth, and where the Turkey Red variety is grown.

Blue grass does well, and its use for pasture is considered profitable. Timothy, Japan millet, and alsike all give good yields. Soy beans are becoming popular as a hay crop on Muck.

Raw Muck land is valued at $50 an acre or more; cultivated Muck sells for about $100 an acre, and some of the well improved areas are held for $150 per acre.

In growing onions on Muck, larger quantities of fertilizer, particularly phosphate, should be used. Muck soils which are overrun with such plants as huckleberries and dewberries, and which do not produce cultivated crops satisfactorily after being drained and plowed, even where treated with manure and potash, are acid, and require the addition of 3 or 4 tons per acre of ground limestone or marl together with liberal applications of phosphate and potash. However, the extent of unproductive Muck in Starke County is very small and usually no treatment other than the addition of potash is needed.

The first requirements in bringing the Muck under cultivation, is drainage. After drainage has been established, the cost of plowing the new land is estimated at about $2 per acre, using a tractor for motive power. By this means, the heavy growth of weeds and shrubs is turned under at the first operation.

Compacting the new Muck soils by means of heavy engines and rollers is highly beneficial. It renders the soil firmer, prevents drifting, lessens evaporation from the surface, and reduces the danger of injury to crops by frosts.

The practice of burning over Muck land is not to be recommended except under certain conditions. In many instance, the burning of Muck, especially the shallow areas results in great damage; very often the burned spots are made unproductive. After Muck is burned over, it grows up in the willows, buttonwood, and dogwood. Muck fires are not troublesome at present in this county.

A great many of the Muck areas remain unreclaimed and

uncultivated, and there is yet room for the more extensive production of the special crops to which the soil is admirably adapted.

Muck, sandy phase—This phase consists of soil that is too mucky to be classed with the Clyde fine sand or fine sandy loam and yet contains so much fine sand that it does not have the properties of true Muck. The material to a depth of 12 to 18 inches is quite black and loose; the underlying material usually consists of grayish fine sand. The mucky layer does not exeed 3 feeet in thickness. In places, the phase is similar to the typical Muck except that is has a higher percentage of light gray fine sand; it was formed under similar conditions, but larger quantities of sand have accumulated in the areas mapped as the phase. In a few places, the nineral matter had been washed in by overflows from drainage canals.

The Muck, sandy phase, occurs as small, isolated areas scattered throughout the county. The largest body occurs in sections 10 and 3, T. 32, R. 1. The areas of the phase usually adjoin areas of Muck, grading imperceptibly on the other side into the Clyde fine sandy loam. The surface is flat, and all the areas originally were marshy. Most of the phase has been reclaimed by deredging, and is now farmed. Under cultivation, it gives good results with wheat, onions, potatoes and peppermint, but as a corn and oats soil it is inferior to the Clyde types. Timothy does well.

Muck, shallow phase.—The Muck shallow phase, comprises a large area in Jackson Township along the Kankakee River. It is essentially different from the typical Muck, and can not be classed with the Clyde soils on account of the small quantity of mineral matter in the surface section. To a depth of 8 to 20 inches, the soil is a black Muck or fine sandy Muck or Peat. In places some silt and clay are present. Usually the vegetable fibers can be distinguished in the material. The subsoil consists of a fine sandy loam of gray or bluish gray color with brownish mottlings. The material becomes lighter in texture with depth, grading in places into sand or fine sand.

The surface is firm and can be driven over without miring, except in saturated spots. This phase was once a part of the extensive Kankakee marsh. It was generally inundated and was largely inaccessible before the dredging of the Kankakee River. It is now free of surface water, but is either subject to inundation or the water table is too near the surface for the land to be farmed successfully. The only agriculture practiced is the cutting of

marsh hay. The hay is composed mainly of sedges, which reach a height of 4 or 5 feet and grow very luxuriantly. The hay is cut with mowers from the last of September until cold weather. It sells for $6.50 to $7 per ton.

Most of this land is held for $40 or more an acre.

With the deepening of drainage outlets, this should become a valuable soil for farming.

Drainage.

Drainage is and always has been the basic problem of this general region. From Marshall County westward along the south side of the Kankakee River there is insufficient relief for the development of drainage ways for a distance of 20 miles or more south of the river. Most of this area was inundated, either permanently or a part of the year, and presented a forbidding waste of marshes and sand ridges to the early settlers.

In the fifties, considerable ditching was done by the State from money obtained from the sale of the lands, but most of this work was ineffective because of the lack of sufficient outlet. The Kankakee River overflowed each year and spread over a wide area. It is said that the country from Hamlet westward to the Kankakee as late as 1890 was a shallow lake.

The first successful large drainage project was the Robbens Ditch, which was completed about 1892, and provided drainage for some of the best land in the county. The Kankakee River was dredged and deepened in 1901. At that time it was dredged from its source in St. Joseph County to the western boundary of Starke County, a distance of about 46 miles. The average bottom width of the river as improved is 50 feet; its depth in water averaged 9 feet. Another stretch of the river, extending about 27 miles from the western boundary of the county, is being improved. The bottom width of this part of the river as improved is 70 feet.

Most of the drainage work in Starke County has been accomplished in the last 15 years. The cost of the public drainage and river improvement thus far accomplished and in contemplation, borne by the land owners, is approximately $2,500,000. The State of Indiana appropriated $65,000 for the removal of a rock barrier in the channel at Momence, Illinois. The attempt to remove the Momence rock, however, was unsuccessful. There is a general belief that this rock will have to be removed before a satisfactory drainage system can be developed.

Yellow River, Eagle Creek and Bogus River have been dredged, and many miles of dredged ditches have been completed. The main laterals and sublaterals are 16 to 20 feet wide and 6 to 10 feet deep, with banks having a slope of 45 degrees. There are some small laterals of 2 to 6 feet bottom width, and 6 feet in depth. The fall near the river is 6 to 12 inches per mile, but farther from the river there is a fall of 1 to 5 feet per mile. Laterals more than one-half mile apart are not considered satisfactory in providing thorough drainage. Most of the ditches apparently do not draw from a distance of more than 500 to 600 feet. The dredging costs from 5.6 to 7 cents per cubic yard, or about $900 to $1,000 per mile. The drainage assessment is $5 to $10 per acre drained. The cost of drainage has been so heavy that at present the landowners do not favor the extension of expensive reclaimation projects.

Some difficulty is experienced in keeping the dredges open. They fill with sand and muck and in many cases require cleaning 1 year to 4 years after they are dug. This work is done mainly by fleating dredges carrying long looms which throw the excavated material over the original banks.

Some tile drainage has been installed within the past five years, with varying degrees of success. Much remains to be done in perfecting the tile drainage systems. The soils are comparatively easy to drain, if good outlets are provided. The tiles ordinarily are placed about 3 1-2 to 4 feet deep and about 10 rods apart, leading to the ditches. Tile is laid near the sand ridges to catch the drainage from the higher areas.

In some Muck areas it is thought that the water table has been lowered too far, so that the crops are likely to suffer from drought. The installation of concrete drains with control gates at the main canals, to prevent excessive drainage and form a supplemental subirrigation system has been advocated, but this would add materially to the present cost of drainage, and it is doubtful whether the plan would prove profitable. In some Muck areas, the closing of the drains in midsummer by inserting sheet iron between the tiles near the outlet or at several places in the drain has been recommended. This would no doubt prove advantageous especially in growing celery, cabbage and other shallow rooted crops.

To drain the average land in the county costs about 30 cents per rod, or $5 to $6 per acre. The elaborate drainage system is being extended each year. About 20 miles of dredging is to be

done in 1916. There are several hundred acres bordering the Kankakee and lower Yellow River that can not be used for agriculture and other areas that can not be cultivated with a reasonable degree of safety except under particularly favorable seasonable conditions. Approximately 35 to 40 per cent of the county is unreclaimed. This land is overrun with scrub oak or is undrained. This land is overrun with scrub oak or is undrained and marshy, and is unsuited to agriculture in its present condition. In 1913 a total of 25,477 acres of timber land is reported in this county. The average cost of clearing scrub oak land is $5 to $10 per acre. Owing to the nearness of the Chicago markets and the good railroad facilities available, the development of these unreclaimed lands apparently offers excellent opportunities.

Drainage authorities are of the opinion that the most feasible and complete solution of the drainage and flood problems of this region lies in the construction of a permanent system of levees along the Kankakee River, with an adequate channel between.

Summary.

Starke County is situated in the northwestern part of Indiana. It has an area of 200,960 acres, or 314 square miles.

The county lies almost entirely within the Kankakee plain, a region of very flat topography except for scattered dune-like ridges and irregular areas of sand which rise from 5 to 40 feet above the plain level. A small morainic area occurs near Round Lake, just east of Bass Lake, and along the Marshall-Starke County line.

Practically all the flat lands throughout the county originally were in a poorly drained condition; large tracts were little more than open morass, and the Kankakee River, the main drainage outlet, was a shallow, sluggish stream which frequently overflowed its banks and spread out over large areas along its course. In recent years the Kankakee River has been dredged, also the Yellow River flowing westward through the center of the county, and numerous large dredged ditches have been constructed to drain areas not reached by natural drainage ways. The cost of the drainage work completed and in contemplation approximates $2,500,000. A large total area is yet unreclaimed.

The average elevation of the county is about 700 feet above sea level.

The county was organized in 1852. A few settlements had been made as early as 1840, but the main development of the county has taken place since 1890 when the drainage of the flat or black lands was undertaken on an extensive scale. The population in 1860 is reported as 2,195, while in 1910 it is given as 10,567 or an average of 24 persons to the square mile. The greatest increase occurred between 1890 and 1900. The entire population is reported by the census as rural. Knox, the county seat and largest town, has a population of about 1,800. North Judson is an important railroad town, with a population of about 1,500.

The transportation facilities are exceptionally good. Two main lines of the Pennsylvania system, the New York, Chicago & St. Louis, the Chesapeake & Ohio, and the Erie, all through lines from Chicago to east and south, and a branch of the New York Central Railroad cross the county.

The county has an extensive system of public roads, and nearly half of them are improved with gravel and stone.

The climate is healthful and fairly well suited to farming. The average annual precipitation is about 36 inches; it is well distributed throughout the year. The mean annual temperature is reported as 49 degrees F. The average growing season is 156 days, or a little over 5 months.

The resources of the county are purely agricultural. The early settlements were made on the well drained morainic lands in the southeastern part and some of the elevated sandy areas through the Kankakee plain, as at that time the flat lands were undrained and considered worthless for agriculture. Later, with the development of artificial drainage, the flat or black lands were rapidly taken up, and now a very large percentage of these lands are improved, and support a prosperous agriculture. Corn is the chief crop. Oats are next in importance, with about half the acreage of corn, and wheat ranks third in acreage. Cowpeas and rye are the most extensive crops on the light sandy lands, while onions and peppermint are important crops on Muck. The county ranks third or fourth in the state in the production of potatoes and first in the production of onions. Stock feeding is followed to some extent, but has not yet developed into an extensive industry. Dairying and hog raising are of considerable importance.

The use of commercial fertilizers has rapidly increased in the last few years. It is considered advisable to use potash fertilizers on all the black lands of the county, including Muck. Phosphatic

fertilizers are widely used for both truck and general farm crops. Liming is becoming popular.

According to the 1910 census, about 81 per cent of the county is in farms, and of the farm land 67 per cent is improved.

Satisfactory farm labor is generally scarce.

The average size of farms in the county is reported as 114.3 acres. The census reports about 70 per cent of the farms operated by the owners, and the remainder by tenants, who rent mainly on the share basis. Land values have rapidly increased in recent years. Improved areas of the light sandy lands sell for $50 to $75 an acre, the Clyde soils from $50 to $140 an acre, and well improved Muck for about $150 an acre.

Throughout the Kankakee plain portion of the county, the soils are derived from water-laid deposits or water-deposited material subsequently drifted by the winds, as in the dune-like ridges and elevated sandy areas. In the flat areas, the soils are high in organic matter, ranging from dark gray to black in color. All the dark soils are classed with the Clyde and Newton series and Muck. The lighter, better drained soils from water-laid material are classed with the Plainfield series, and the till soils of the morainic areas with the Coloma and Miami series. The alluvial soils are classed with the Griffin series.

The Clyde series is represented by the fine sand, fine sandy loam, and loam members. These are dark gray to black soils resting upon gray mottled subsoils of similar to somewhat heavier texture. The fine sand and fine sandy loam are extensive types, and constitute a large part of the best improved land of the county. Corn, wheat and oats are the chief crops.

The Newton series is characterized by dark gray surface soils and the yellowish subsoils, representing an intermediate condition between the Clyde and Plainfield soils. Only the fine sand type occurs in this county. It is not extensive, and a large proportion of it is undeveloped scrub-oak land. In spots, it is in a highly acid condition, and large applications of lime are required to make it productive.

The Plainfield series includes brownish gray to light brown or yellowish brown surface soils, with yellow to light orange colored subsoils of similar texture. The fine sand member is extensively developed in Starke County. Most of the rolling phase and probably not over 50 per cent of the level ares are cultivated Cowpeas and rye are the main crops. Corn and oats give light and uncertain yields.

The Coloma series includes only one type, the fine sand. In color and structural characteristics it is very much like the Plainfield fine sand, but differs from that type in being derived from ice-laid material and in having a distinct morainic topography and more or less stone on the surface and throughout the soil section. It is of small extent, and occurs near Round Lake, east of Bass Lake, and along the Marshall County line. Nearly all the type is cleared and under cultivation, and gives light to fair yields of corn, cowpeas and the other crops grown. The average yields are somewhat higher than on the Plainfield fine sand.

The Miami series includes till soils of brownish-gray to light brown color with yellowish brown, heavier subsoils. The material is calcareous at depths of 2 to 3 feet. The fine sandy loam is the only member mapped, and it is not extensive. Practically all this type is under cultivation and highly improved. Corn, wheat timothy and clover are the main crops.

The Griffin loam and fine sandy loam are brown soils with gray and brown mottled subsoils, developed along the Yellow and Kankakee Rivers. The loam is highly productive. Most of the area along the Yellow River, where the drainage is fairly good, is cleared and produced heavy crops of corn, wheat, oats, clover and other crops. Only a small part of this soil is under cultivation.

Muck is very extensive in Starke County. A large acreage is improved and used for the production of onions, peppermint, and potatoes. Corn, oats and wheat are grown to some extent with varying degrees of success.

Fountain County Soil Report.

By C. H. Orahood.

Location: The Wabash river follows the boundary line of Fountain County on the north and west sides. Warren County lies across the river on the north. On the west, the Wabash separates Warren and Vermillion counties from Fountain. It lies north of Parke and west of Montgomery and Tippecanoe counties.

Area: If a line be drawn east from Fountain, a village on the Wabash river between Attica and Covington, to the county line and one south to the county line, it will form a rectangle with sides, 19 and 17 miles. On the north there would be a triangular body of land containing approximately 69 square miles. On the west there would be a strip of land along the River containing about 79 square miles. The county includes nearly 400 square miles. It has a maximum length of 28½ miles, and a maximum width of 18¼ miles.

The range in elevation so far as known is from 500 to 700 ft. The region about Hillsboro in the eastern part of the county, with an elevation of 728 ft., is the highest in the county. There are points in the southern part of the county, about Yeddo and Kingman, that reaches an elevation of 707 to 712 ft. The lowest portion of the county is in the south-west part, where the Wabash leaves the county and has an elevation of 500 ft.

Drainage: With the Wabash river flowing along the north and west sides of the county and the general slope to the west and south, the natural drainage for the most part is good.

In the northern part, Big Shawnee flows entirely across the county from east to west and with its tributary Little Shawnee, makes up the principal drainage system of that portion of the county.

Coal creek and its tributaries make up the drainage system of central Fountain. Its source is in Montgomery county. Its course for over half the distance is practically parallel to Shawnee. But at Ayelsworth it swings abruptly to the south and its channel sinks deeper into the earth. The tributary streams have cut the adjacent region into hills and valleys. From Stone Bluff to the county line the stream is relatively sluggish, the country a comparative plain, no hills encountered as the stream is approached.

At Veedersburg the East Fork of Coal creek enters the main stream and from here the stream assumes a southwesterly direction to its confluence with the Wabash, a short distance below the boundary line.

The East Fork has a deep channel for most of its course across the county and the eroded hills present some rough topography. This rough area does not extend to any great distance back from the main stream. Sandstone and shale are exposed profusely along this stream in the vicinity of Hillsboro.

Prairie creek, a tributary to Coal creek, and Wabash Mill creek, drain the southern portion of the county. The southeastern corner of the county is cut up by Sugar Mill creek and its tributaries.

Bear creek with its tributary Rattlesnake creek flow through a deep sandstone gorge at Fountain. Here is located a summer resort of no little distinction, called Portland Arch. The narrow sandstone divide that formerly separated the small tributary from Bear creek has been worn through and now the stream flows through an arch in the solid sandstone wall.

Soil Discussion.

Soil, is broken bits of rock, either very fine or relatively coarse, along with organic matter. The top soil, or that which is usually spoken of as "the soil", is the layer uppermost and varies in thickness from three to twelve or fifteen inches.

The subsoil is that portion of the soil between the top soil and bed rock. Soil is the product of the various agencies of weathering. Heating and cooling causes an unequal expansion and contraction of rock surfaces, breaking them into fragments. These fragments, in turn, are acted upon in the same manner and broken into smaller and smaller bits. The pores of rocks fill with water, the water freezes and expands, bursting the rock. Water in passing through the air, takes on carbon dioxide. Water so charged, dissolves certain rock substances. Caves and caverns are often formed in this manner. By solution, then, rocks are being worn away. Roots of trees and plants aid materially in breaking rock especially bed rock.

Glaciers moving over rock surfaces grind the rock to fragments and "rockflour". This material may be carried several miles and deposited in moraines or heaps, giving the region a billowy or rolling to hilly topography. Soils that are formed by glacial

action are called glacial soils. The soils of Fountain county are glacial soils. In the above mentioned ways and others, rocks are ever changing into finer and finer particles. This finely disintegrated rock material constitutes the mineral matter of soils.

From these minerals such plant food as phosphorus, iron, potassium, sulphur, calcium and others are derived.

The productivity of soils is determined by the rock of which it was formerly a part.

Shales weather into clay soils and are often cold and clammy and hard to work, but more productive than soils derived from sandstones. Limestone usually weathers into a very fertile soil provided the lime constituents have not been dissolved out. Soils derived from granite are usually rich in potash and as the supply decreases, due to cropping or leaching, there is a constant renewal as the small grains of feldspar dissolve. These potash-bearing grains may not dissolve rapidly enough to furnish sufficien potassium for maximum crop production and the yields decline. For this reason, that much potash is locked up in these mineral particles, chemical analysis of soils cannot be relied upon to determine the mineral plant food constituents. The chemical analysis, for example, may show sufficient potash, while this is present yet, it may not be in available form for plant use. It may be held tightly bound in these minute rock particles and not being released rapidly enough to supply the plant requirements. Then the chemical analysis may be misleading if this fact is not understood. The coarseness or fineness of the soil particles is the factor that determines the texture of the soil. In order of finest to coarsest, these soil particles are, clay, silt, sand, gravel, and stones.

Clays are soils that contain as much as 25 per cent of clay and usually contain much silt.

Clay loams contain from 15 to 25 per cent of clay, mixed with much silt and some sand.

Silt loams are soils that contain more than 50 per cent of silt and with less than 15 per cent of clay and some sand.

Loams contain 30 to 50 per cent of sand and mixed with much silt and some clay.

Sandy loams contain 50 to 75 per cent of sand.

Fine sandy loams contain 50 to 75 per cent of fine sand, much silt and a little clay.

Sandy soils contain more than 75 per cent of sand.

Gravelly loams contain 15 to 50 per cent of gravel, with much sand and some silt.

Gravels contain 50 per cent or more of gravel.

Stony loams contain a large number of stones, from an inch and over, in diameter.

In order that certain distinctions may be brought out by a soil map, certain names have been added to the soil types in order that the map will show whether a given type is bottom along streams, or a terrace soil, prairie or upland soil. If the map merely showed on a given area there was present a silt loam, it might be upland or prairie soil, in color it could be gray, brown or black.

Certain names have been applied to the first bottom series, terrace series, black prairie soils, upland soils, and others. These names are not fixed as yet but there is an effort to better systematize in the future surveys.

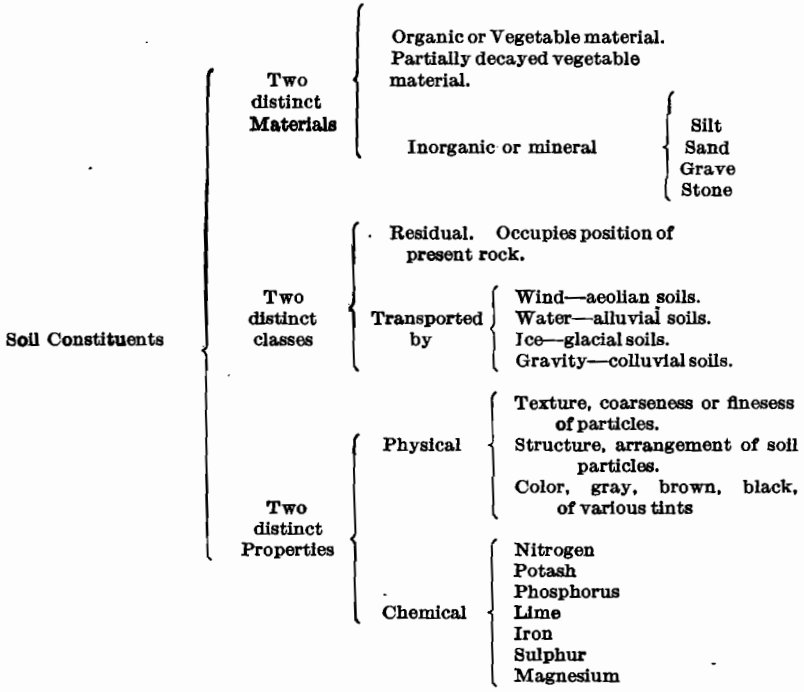
The Fox Series are terrace soils. The soils of the Genesee Series are confined to first bottoms along streams and is subject to seasonal overflow. The soils of the Clyde Series are dark colored, dark because of the great amount of organic mater present, and are chiefly prairie soils. The rich dark brown soils, associated with this series in north Fountain have been mapped as Carrington silt loam. The Carrington silt loam consists of a dark brown to black soil, associated with it are gravelly knolls or ridges crossing the area. The soils of the Miami series are distinguished from the Carrington series by their prevailing light-brown and gray surface soils and the mottled yellow and brown subsoil. Areas of Clyde silty clay loam are associated with the Miami series in the southern portion of the county.

The above examples show the meaning and necessity of using some method of classification as this.

Soils are made up of two distinct materials, namely, organic and inorganic or vegetable and mineral matter. Soils are divided into two classes, residual and transported. Residual soils are those soils that remain above the solid rock from which they were formed. Transported soils are those soils that have been carried from the place they occupied previous to weathering from bed rock.

Decayed rock, when sufficiently weathered, becomes soil. The parent rock largely determines the fertility of the soil.

The following outline is useful in the study of soil constituents:



The land in the southern portion of the county and the uplands bordering the Wabash river is suffering great losses due to erosive work of stream action. Much of the best portion of the soil is escaping rapidly. Each year gullies are lengthening into valleys, and the tillable areas are decreasing.

Shale deposits may be used up and coal beds disappear, but the soil must be saved. This land must be recovered from the hazardous grasp of erosion. Much more rapid erosion is allowed than necessary, if proper methods of prevention are applied.

It is high time that mankind awoke to the fact that without proper heed and careful, scientific methods of agricultural practices the soil is not indestructible, neither are the plant food elements inexhaustible. Lands subject to erosion along streams should be kept free from the scar of the plow.

The timber of such areas should not be cut too closely and the land used for grazing. Brush, straw or any coarse material thrown in the gully will hasten its disappearance by its own action.

The muddy rivers and streams are proof positive that the soil is being carried away.

The essential soil constituents are also being exhausted in another way. Products of the soil, directly and indirectly, supply the necessities and most of the luxuries of mankind. Plant life requires along, with other elements, potassium, phosphorus, and nitrogen. When a crop is removed from the soil a certain amount of these elements is removed. Little reasoning is required to show that if this process is kept up without the addition of any of these elements to the soil that its producing power will decrease if not finally fail.

*The following Table shows the approximate maximum amounts removable per acre annually of the three principal elements.

Produce.		Pounds		
Kind	Amount	Nitrogen	Phosphorus	Potassium
Corn, grain	100 bu	100	17	19
Corn, stover.....	3 Tons.	48	6	51
Corn crop.....	.....	148	23	71
Oats, grain.....	100 bu.	66	11	16
Oats straw.....	2½ tons	31	5	52
Oats crop.....	.....	97	16	68
Wheat, grain....	50 bu.	71	12	13
Wheat straw.....	2½ Tons	25	4	15
Wheat crop.....	.....	96	16	58
Clover hay.....	4 Tons	160	20	120

With the chief plant food elements disappearing at this rate what wonder that farms under poor scientific care are being abandoned. In a system of grain farming the loss to the soil is very great, but in a system of stock and grain farming combined, this loss is greatly diminished, though not altogether eliminated.

Scientific investigations show that at least 80 per cent of all fertilizing constituents present in the materials fed on the farm is voided by the animals in the solid or liquid excreta. Then the value of the manure produced from a ton of feeding material of the farm may be ascertained by taking 80 per cent of the fertilizing value of that material. With these facts at hand, the conclusion is, for the lands sake, feed the products of the soil on the farm.

*From G. C. Hopkins, Soil Fertility and Permanent Agriculture.

The Clyde Series of Soils.*

In color the soils of this series are brown, dark brown or black. The natural drainage is usually deficient and artificial drainage must be resorted to in order to bring them to the maximum of productiveness of which they are capable.

The swampy areas left by the retreating glacier supported a luxuriant growth of vegetation. The vegetable remains deposited annually by the plant growth has supplied the organic matter that gives to this soil series its potential power for abundant crop yields.

Clyde Silty Clay Loam.

The dark brown to black soils of Fountain county usually found in depressions, naturally poorly drained, locally called black ground, represents the Clyde silty clay loam of the county. The soil varies in depth from 9 to 15 inches, underlain by a dark brown silty clay loam which gradually changes into a dark blue clay or clay loam as depth increases. It is associated with the Miami series in southern Fountain and with the Carrington silt loam in the north-central portion. The Clyde silty clay loam requires careful handling, for if plowed too wet it is liable to become cloddy and its power to produce is materially lessened.

Corn is the chief product of this type and yields from 50 to 90 bushels per acre.

Fountain county has three distinctive prairie regions. Scotts Prairie, southwest of Hillsboro, contains some of the richest soil in the southern part of the county. Farms are well drained and well kept, beautiful homes and farm buildings indicate the prosperity and energy of the people.

Sharvnee Prairie, in the region of Newtown, represents a large area of soil of wonderful producing power.

Osborne Prairie lies between Covington and Stone Bluff, this region is no less productive than the other regions mentioned.

Smaller areas, but known for their richness, are found northeast of Kingman and northwest of Yeddo.

The portion of this type that occupies the depressed areas are heavier, containing more clay and have in some cases been classed as Clyde clay loam.

At the margins of some of these areas a fine sandy loam is found which may indicate the edge of a former lake.

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*For a full description of this series see, Bul. No. 141 U. S. Dep. Agr.

The Miami Series.*

The surface soils of this group are light brown to ashy gray in color. The subsoil is yellowish-brown to mottled gray and brown. The topography varies from relatively flat in the flat phase to gently rolling and ridged. Along the larger stream courses and their tributaries rough and eroded surfaces are conspicuous. Much of this type requires drainage before best production is attained. In early times, trenches were dug and into these, poles and brush were piled and covered. Flat rocks were sometimes used in a similar manner. Later, sawed boards fastened together, not unlike the culverts of a short time ago.

These methods furnished temporary relief. At present drain tile are made of clay. The chief source of clays for drain tile in Fountain county is the Pleistocene formation. These drift clays are easily accessible, hence, little equipment is required for getting it to the mill and an excellent drain tile at a relative low cost to the farmer.

Although the more rolling portions of this type apparently do not need tile drainage as much as the relatively flat areas yet most soils respond favorably when such service is rendered.

The prime purpose of drainage is to lower the water table, this however, involves several other vital factors. Standing water shuts off the air from the roots of plants and they are drowned. The presence of water makes the soil cold and prevents early seeding, thus shortening the growing season.

Tile drainage removes the surplus water and brings in air. Ofttimes, after a heavy rainfall, bubbles may be seen escaping at the surface from earthworms runs, this is air being forced out from between the soil particles and being replaced by water. When the natural drainage is poor, and there are no tile drains, a large per cent of the water evaporates from the surface, there being no way for escape below. The lowering of the water table by surface evaporation is a slow process. But when the land is tile drained the surplus water passes down through the soil into the tile and fresh air comes in from above to replace the water. It is important that the soil be well aerated to supply oxygen to the roots of plants. Microscopic organisms of the soil require oxygen.

The bacteria that live on the roots of the legumes utilize the free nitrogen of the air, when the supply is shut off by a water

*For full discussion see, Bul. 142 Miami Series of Soils, U. S. Dep't. Agr.

filled soil, they cannot live. Tile drains enlarges the room for the development of root systems which is an important factor to vigorous plant growth. On rolling land, tile drains prevent washing and formation of gullies.

The Miami silt loam was formerly heavily forested. The more rolling areas produced the sugar maple in greatest abundance, while in the more nearly level areas beech was the predominating tree, but along with it were associated several species of oak, hickory, ash, walnut, elm and basswood. Along the stream courses the sycamore still is holding a footing in its favorite habitat.

Genesee Series of Soils.

The Genesee Series of Soils are confined to first bottoms along the larger streams. They are subject to seasonal overflow and the properties of a given area may change from season to season. This year a given area may be a sandy loam, next year, after the seasonal overflow, the area may be a silt loam or a gravelly loam. The Genesee soil is a transported soil. It is an alluvial soil, being brought to its present position by the agency of water.

While the type is well represented along the tributaries of the Wabash, by far the majority of this type is found along Wabash. Corn is the chief product of this type. Corn produces from 40 bushels to 75 bushels, with a probable average of 60 bushels. Occasionally a whole crop is lost, due to the irregular seasonal rainfall of the region. But even with a crop lost every few years there is still some advantages. They need not worry about commercial fertilizer or barn yard manure, for each overflow a top dressing of soil is deposited. While this may be true in the more protected places, yet out in the unprotected regions washouts often occur, ruining whole fields, or sand bars may be deposited, fertile fields changing them from productive and fertile fields in a few days time to little better than barren wastes.

Fox Series of Soils.

The soils of the Fox series are terrace soil, along the larger stream courses. They represent what was once the level of the channel. The stream, in wandering back and forth between the banks, cut the upland down. Then sinking to a deeper channel, has left this upper bottom and set to work cutting out again, perchance, in a different direction. Sometimes, on this side, then on that side of its course. A stream channel is ever changing.

At the extreme southwest corner of the county, probably in the near future, the Wabash river will cut across the bottoms, where it makes the sharp turn to the east and leave the wagon road as well as the railroad bridge across its deserted channel, necessitating the building of bridges at a point further west.

The terrace soils vary from a silt loam to a sandy and gravelly loams.

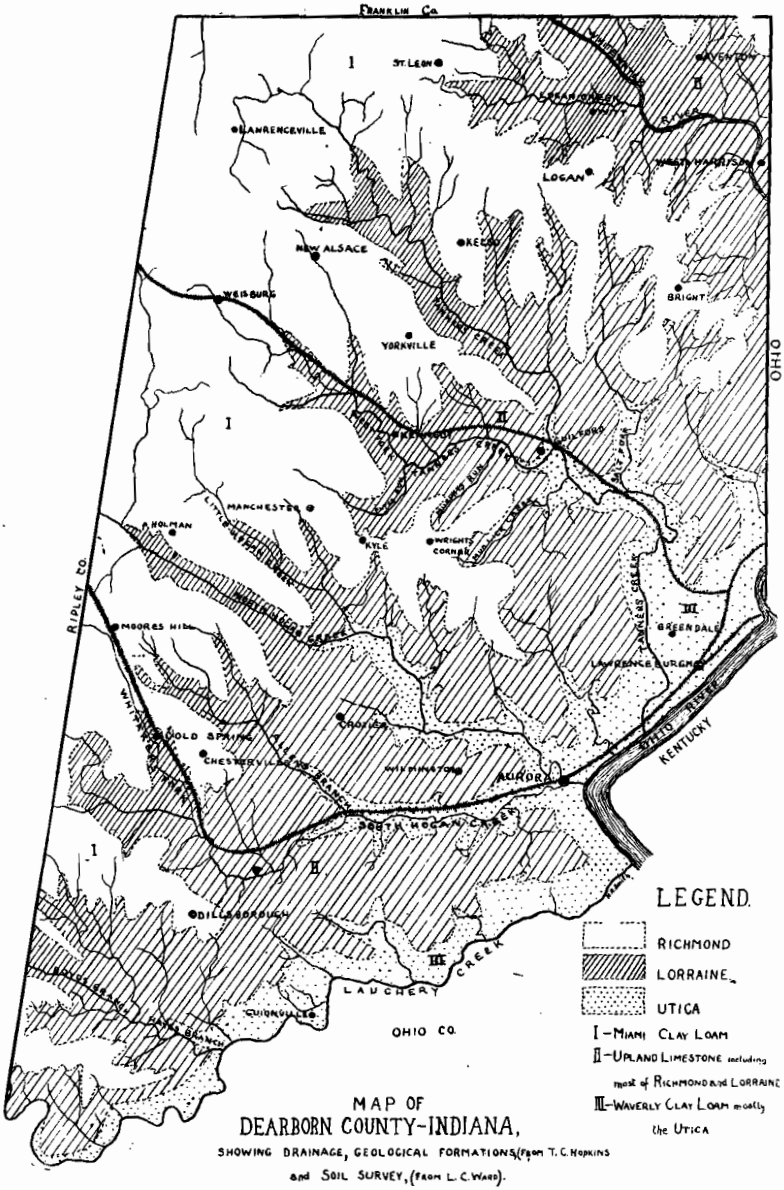
Climate of Fountain County.

Annual mean temperature	52 deg. F.
Average date of last killing frost	April 28.
Average date of last killing frost in autumn	Oct. 6.
Average annual precipitation	36 in.

Attica, with a population of 3,300, is the largest city in the county, and is located on the Wabash, in the northern part of the county.

Covington is the county seat of the county and is situated on a terrace of the Wabash.

Veedersburg, the hub city of the county, has a population of 1,750.



MAP OF
DEARBORN COUNTY-INDIANA,

SHOWING DRAINAGE, GEOLOGICAL FORMATIONS (from T. C. Hopkins and SOIL SURVEY, (from L. C. Ward).

Geology of Dearborn County.

By A. J. Bigney, President Moores Hill College.

Historical Statement.

Dearborn County was named in honor of Major-General, Henry Dearborn, Secretary of War, under Thomas Jefferson. It was carved out of the northwest Territory. When Indiana Tertriory was organized in 1800, the western boundary of the present county of Dearborn was a part of the old Indian Boundary Line.

In 1802, Ohio was admitted into the Union as a state. The boundary was moved east to the mouth of the Miami River, thence, north, which is now the boundary between Indiana and Ohio. and thus, the eastern boundary of Dearborn County. The people who settled in the County came mostly from Virginia, Ohio, and Kentucky, as early as 1796, and settled on the bottoms, north of Lawrenceburg, along the Miami, and on the present site of Lawrenceburg and Aurora. The county was organized March 7, 1803.

Location and Size.

Dearborn County is located in the southeastern part of the state, bordering on the Ohio River, eighteen miles below Cincinnati. Its area is 309 square miles. Its length is 26 miles and its breadth 16 miles.

Topography.

Dearborn County is drained by the tributaries of the Ohio River. On the south the Laughery Creek forms the boundary and drains that part. It empties into the Ohio River, two and one-half miles south of Aurora. About six miles to the north and running nearly parallel with Laughery Creek is South Hogan, which empties into the Ohio at Aurora. The B. & O. S. W. R. R. follows it to Aurora. Between these creeks is a ridge of good farming land. Flowing from this ridge, from either stream, are numerous branches. About eight miles further north, measuring on the west side of the county, is North Hogan, which joins South Hogan at Aurora. About the same distance to the north is

Tanner's Creek. The Big Four follows it much of the way to Lawrenceburg. The northeastern part of the county is drained by the great Miami River, the main Indiana branch, being the Whitewater. With so many streams of various sizes it is plain to see the county is very hilly, no part of the county having much level land.

These streams, necessarily, have formed narrow deep valleys with steep slopes and usually with a rapid fall. The Ohio River has cut a gorge on the east side of the county about 400 feet deep. The bluffs, thus overlooking the river, present most picturesque ridges. From Laughery to Aurora the bluffs are close to the river, there being some alluvial land widening on approaching Laughery. Above Aurora, the bluffs gradually recede from the river, thus making extensive bottoms between Aurora and Lawrenceburg nearly two miles wide. These hills continue up the river and join those bordering the Miami River. At the B. & O. S. W. depot at Aurora, the elevation above sea level is 490 feet. Advancing up the creeks from the Ohio the ridges decrease in elevation until the level uplands are reached on the western border of the county at an elevation of 918 feet at the Moores Hill depot, and at Milan, just beyond the county line, 985 feet, and at Sunman, Ripley County, 1014 feet. The fall on Tanners' Creek in 16 miles is 400 feet, and on the Hogan Creeks, 425 feet in the same distance.

Geology.

Dearborn County is located on the western slope of the Cincinnati arch, not far from its center. The slope is so slight that it is not readily detected. Previous to this uplift this section of the state was a part of the Inter-Palaozoic Sea. Conditions were favorable, sometimes, for the formation of extensive strata of limestone, while at other times, beds of shale were deposited. As these strata arose from the ocean, erosion began which has continued through the countless ages to the present so that this region has become topographically mature in its drainage as exhibited in the discussion of the Topography of the county.

To give the reader an idea of the relation of this region to the other geological formations a resumé for central North America of the legends is here given:

Archaeozoic—The oldest rocks, outcropping mostly in Canada north and east of the Great Lakes.

Proterozoic—Next in age, in the region of Lake Superior.

Palaeozoic—Following and outcropping in the greater part of the Mississippi valley.

Cambrian—The oldest of the Palaeozoic strata in the region of the Great Lakes.

Ordovician—Next in age, in adjacent parts of Ohio, Kentucky and Indiana, known as the "Ordovician or Silurian Island".

Canadian—The oldest of the Ordovician rocks in southern Canada.

Mohawkian—In New York as Trenton, and also near Patriot, Indiana.

Cincinnatian or Hudson River—In the region of Cincinnati.

Utica—Lowest along Ohio River and in the beds of inflowing streams.

Lorraine—Above the Utica.

Richmond—On the highlands in western part of Dearborn County.

Silurian—Formations west of the Ordovician, beginning on Laughery Creek.

It will be noted that Dearborn County is covered with strata belonging to the Cincinnati division. This indicates that the region is very old, considered from a geological standpoint.

The subdivisions—the Utica, Lorraine, and Richmond will now be considered in detail.—

The Utica strata consists of shales, blue in color, containing relatively few fossils, interstratified with thin beds of impure limestone. These shales at the Ohio River are the lowest and are about 40 feet thick. The Utica shales may be traced up Tanner's Creek and the Hogans about 10 miles and up Laughery about 16 miles. These shales are found in the bottom of the creeks and is commonly spoken of as blue clay. Much of this clay is quite pure and may be used for making anti-phlogiston.

The Lorraine lies directly above the Utica and consists of shales and limestones similar to the Utica, but with more limestone—the strata being thick enough to be useful for road building. The hills overlooking the Ohio are capped with Lorraine limestone—the greatest thickness being 260 feet.

The Richmond formation covers the western part of the county and consists largely of limestone with thin beds of impure clay interbedded. Much of this limestone has decayed, thus helping to form new soil. Fossils abound in this limestone, rendering it so brittle that it has no economic value. Its thickness is about 65 feet.

Economic Geology.

From an economic standpoint, Dearborn County is not as important as many counties in the state, yet this feature must not be undervalued. Since the development of the county depends very largely upon the condition of the roads, it is worthy of special mention that the county is rich in the materials for building roads. Limestone abounds in most parts. The mantle soil is from five to fifteen feet in thickness. Where much erosion has occurred the outcropping limestone is easy of access. Along all the creeks an abundance of fragmentary rocks are accessible for roads and concrete work. In many parts of the county quarries have been opened for furnishing the material for building pikes. The distance that the stone must be hauled figures quite largely in this industry. The past ten years has witnessed a marked increase in the mileage of pikes constructed. The increase in the use of automobiles has made a greater demand for good roads. The automobile has really solved the problem of the roads. The people are now willing to pay the price of good roads. With the material at hand the roads in time will be made. No building stone of any consequence is found, except for cellars and foundation purposes. The thickness of these stones varies from four to eight inches with occasional strata a little thicker.

Another kind of material that is valuable for roads and all kinds of concrete work is the sand and gravel. Along almost every creek, especially along the larger ones there is considerable, sand and gravel. The quality is not very high, for it is mixed with much clay. There is not enough of this material to supply the demand. Along the Ohio River is to be found the most extensive beds of gravel, sand, and silt, usually somewhat stratified. Some of these beds are twenty-five feet in thickness, and covering several acres. In many of the beds the material is too fine for the roads, thus making it necessary to sift it. The best quality of sand is taken from the Ohio River bed. A detailed report of the road material of Dearborn County is given in the Indiana Geological Report of 1905.

A number of deep wells have been driven in different parts of the county. On the Fair Grounds at Lawrenceburg a little gas was found, but of short duration. In Aurora, near the South Hogan Creek wagon road bridge an artesian well existed for a number of years. The water was of medium medicinal quality and was much used for such purposes. The most successful artesian well is at Dillsboro. It is 1,387 feet deep but the initial pressure is not great enough to force it to the surface by about 300 feet. So valuable is the water that a Sanitarium has been built and the people are going there in large numbers to get the benefit of its healing powers. The analysis of its water is as follows:

	To each Imperial Pint.
Sodium Chloride	18.6 grains
Calcium Chloride	8.1 grains
Magnesium Chloride	20.0 grains
Sodium Sulphate	31.2 grains
Aluminum Sulphate	8.1 grains
Magnesium Sulphate	7.5 grains
Calcium Bicarbonate	7.0 grains
Free Carbonic Acid Gas	00.0 grains
Total	100.5 grains

No metals of any consequence have been found in this county. In a few places the rocks and soil are sufficiently rich in bog iron ore to form a coating on the water flowing from such beds. The inexperienced think this is oil coming from the ground, indicative of the presence of oil in paying quantities. A number of years ago a piece of native copper, weighing about 26 ounces, was found near Weisburg. It must have been brought down from the Lake Superior region in the glacial drift.

Along Laughery creek, about seven miles from the Ohio River, small quantities of gold have been found in the glacial drift. One man obtained eight dollars worth and another sixteen dollars worth. It occurred in the form of dust, fine scales and minute nuggets. More could, no doubt, be obtained if any one cared to wash the drift. This gold also must have come from the Lake Superior region.

PALAEONOTLOGY.

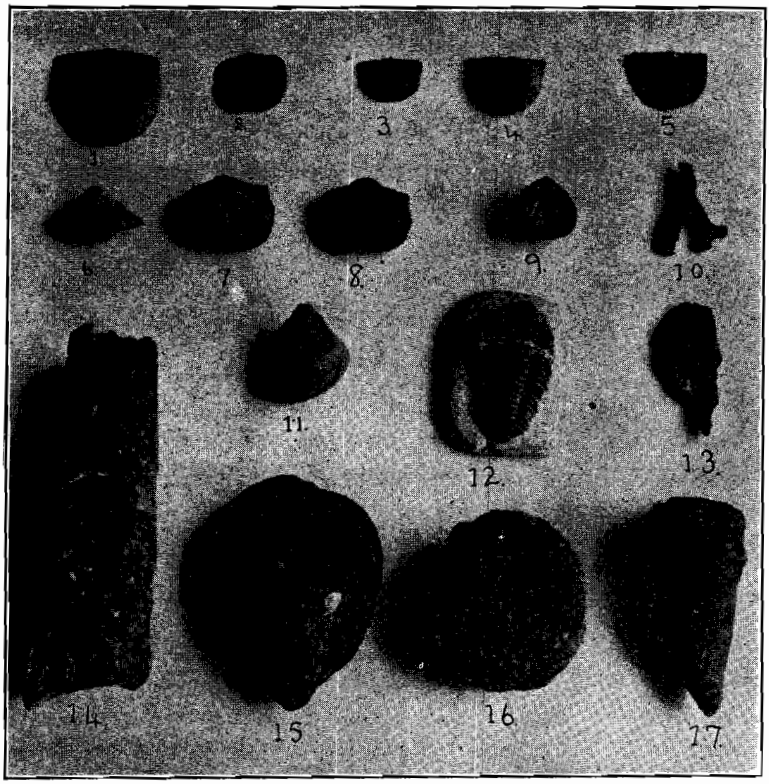
It is not within the province of this paper to give an exhaustive study of the fossils of the county. The purpose is to give such

information as will be most helpful to those with limited training in such subjects. The Ordovician rocks are noted for their richness in fossils. In fact, the fossils are so abundant that the rocks are rendered soft and brittle and unfit for economic uses, except in certain strata. The rocks above the Silurian rocks, outcropping in Ripley County, a few miles to the west, have but few fossils, hence they furnish much good building stone as is seen in the Osgood quarries. Even the inexperienced, with superficial observation, is impressed with the abundance of such structures. They naturally raise the question, "What are these fossils, and whence came they?" One must bear in mind that at one time this region was all under ocean water and this sea was rich in plant and animal life. In due time these organisms perished and being covered with sediment would degenerate slowly. At the same time, stony material, such as limestone, compounds of iron, or quartz in solution would replace the original tissue of the plant or animal, thus causing them to become rock-like. Thus, we say the organisms have become petrified, which word means "made into stone", not actually changed to stone, as many people think, but the stony material replaces that of the original tissue. The "shells" that are found in the rocks are these petrified forms which are called by the geologists "fossils".

To understand these fossils, one must know something about botany and zoölogy. Not many fossil plants are found in these rocks, hence only the animals will be considered. The leading groups of animals represented in Dearborn County are the corals, echinoderms to which the starfish belong, the brachiopode, which are forms with two shells placed together, resembling the mussels in our creeks, but much smaller, the bryozoa, which appear as branched forms or incrustations with many minute openings, mollusks, including snails, mussels, and nautiloid forms, and trilobites which are relatives of our crayfish.

On the accompanying plate are given a few of the typical fossils of the county so that even the amateur may be able to recognize the group to which each belongs.

Those who are interested in a detailed description of the fossils of the county, see 32nd Indiana Geological Report, Page 688, article by E. R. Cummings.



1. A Brachiopod—Strophomena vetusta.
2. A Brachiopod—Strophomena sinuata.
3. A Brachiopod—Leptaena rhomboidalis Wilckens.
4. A Brachiopod—Strophomena planumbona—Hall.
5. A Brachiopod—Strophomena planumbona—Hall. Inside view.
6. A Brachiopod—Platystrophia acutilirate.
7. A Brachiopod—Platystrophia lynx Eichwald.
8. A Brachiopod—Herbertella occidentalis Hall.
9. A Brachiopod—Rhychotrema capax.
10. A Brychzoan—Callopora ramosa d'Orbigny.
11. A Mollusk—a Gasteropod—Clathospira subconica—Hall.
12. A Tribolite—Calymmene Callicephala Green.
13. A Bryozoan—Monticulipora mammulata.
14. A Cephalopod—Orthoceras Carleyi Hall.
15. A Mollusk—a Pelecypod Allonychia jamesi Meek.
16. A coral—Favistella Stellata—Hall.
17. A cup coral—Streptelasma rusticum Billings.

Soils.

The soil of Dearborn County is somewhat varied. The bottoms or alluvial deposits are rich and productive, while the hill lands are rich in possibilities but not so productive. I say rich in possibilities, because many of the fundamental elements are present in great abundance but it requires additions for making these available and then it is very productive.

The soil consists of sand, clay, gravel, limestone, and organic substances. The sand has been derived from the granitic rocks, the gravel from similar sources, the limestone has been made by the animals of the ancient ocean, and the organic substances from the plants and animals of the present.

The soils in the county are divided into three classes by C. W. Shannon in the thirty-second Geological Report of Indiana:

I. The Limestone Upland Soil.
II. The Miami Clay Loam.
III. The Waverly Clay Loam.

I. The Limestone Upland soil is located on the hills, ridges and highlands in the western part of the county. Probably two-thirds of the county is covered with this soil. It consists of the decayed limestone and the shale between the layers of limestone. There is more of the shale on the slopes. The limestone is not completely decayed, there being much of it in the fragmentary form. These fragments are so abundant, especially on the hillsides, that the farmers use them for making fences and for building roads and foundations for buildings. The farmers are also crushing it and using it to destroy the acidity of other soils. Most of the creeks are well filled with these fragments. This stone is rich in fossils and these make it decay more rapidly. This soil is kept largely free from acid and thus it becomes a very valuable soil for most crops, especially fruits of various kinds.

II. The Miami Clay soil is found in the northwestern and western part of the county adjoining Ripley County, where most of the land consists of this kind of soil, especially east of Laughery. It is light in color and quite firm and compact until altered by drainage and cultivation. The "crawfish flats" as this land used to be called is rapidly changing under modern farming. The subsoil often contains sand, gravel, and little concretions of iron and clay. It is mottled with blue, red, and white materials. Beech and sweet gum trees characterize such soil. It is well adapted to

grass and wheat, and when fertilized with clover or barnyard manure or other good fertilizer, produces large crops of corn as well as a great variety of fruits. It holds moisture unusually well, but it must be properly drained. No section of the state has been improved more than this Miami Clay soil. Twenty-five years ago, the farmers on this land could scarcely make a living, but now they are rapidly increasing in wealth.

III. The Waverly Clay Loam is located along all the creeks in the bottoms and chiefly along the Ohio River, between Aurora and the Miami River. In this region more than 7,000 acres are covered with this soil. For the most part it is very rich and productive. It consists of a sand and gravel bed, probably of glacial origin. The surface soil consists of clay, fine sand with some limestone, brought down from the hills, small pebbles, and much humus. This is particularly good for corn and truck farming.

Conservation of the Soil.

Twenty-five years ago most of the hilly land was heavily timbered. Since then, however, the greater part has been removed and the land put under cultivation.

This is where the serious mistakes have been made. Year after year, the hills were planted in corn, barley and wheat. The ground was thereby kept loose and the rains eroded it and transported this rich soil to the valleys below, thus enriching them. As the forests were cleared away the erosion increased, until at the present time the rich black soil is largely removed from the hills and the clay beneath it is now being eroded very rapidly and this new soil is being tranpsorted to the bottom land and deposited upon the rich soil, previously deposited. This not being mixed with humus is not very productive. This is seen on the large bottoms of the Ohio and Great Miami. Twenty-five years ago those alluvial plains produced corn in an extraordinary way, but today their productiveness has greatly decreased.

It is plain to see that the farmers on both the hill lands and also the bottoms have suffered great losses on account of this unfortunate method of procedure. Many of the landowners have seen the error of their way and are changing their method of farming. Alfalfa is now being sowed, and this is protecting the land and at the same time is rendering large profit. Others are sowing to blue grass and using the land for pasture—another wise and productive plan. Still others are setting out locust plants

and in this way they are protecting the land and providing for the future realization of profit. Much of the waste land in the county could very profitably be used in this way. Others are clearing away the little timber that remains and planting this to tobacco, year after year, and in this way the wasting of the land continues.

A large per cent of the farmers have never realized the real value of their land. They have so much of it that it makes very little difference to them even if some of it is going to waste. The time is coming when this county will be more densely populated, and someone will be compelled to reclaim this land waste. Many are so selfish that they do not care; but is this a sensible way in which to act?

The greater number of the landowners do not consider how important the soil is They fail to realize that mankind must look to it as a source of sustenance.

If we could look into the future more and try to see the coming needs it would be better for the present as well as the future generations.

Glacial Drift.

Dearborn County seems not to have been invaded by the Glaciers, except along the eastern border. Important moraines occur along the ridge of hills from Elizabethtown to Lawrenceburg and for several miles along the hills north of Laughery creek. In the latter position are the deposits in which gold has been found. Almost opposite the mouth of Laughery Creek on the Kentucky side of the Ohio River is the famous glacial deposit known as "Spiltrock". This is a terminal moraine of a lobe of an ancient ice-sheet which extended down the Miami valley past Lawrenceburg and across the Kentucky bottoms below Petersburg, Ky. The old course of the Ohio River may be seen along this line. Standing at Splitrock one can readily observe this, and that the river has been gradually shifted westward until it reached the ridge of hills at Aurora which is its present position. Although Splitrock is not in Dearborn County, yet it is the main glacial deposit and directly connected with that in the county.

In addition to the moraines along the eastern border there are glacial boulders scattered over the county, here and there, consisting of rocks having the same composition as rocks of the Great Lake region. Some of these are two to three feet in diameter, but most of them are less than one foot. Most of the clay and

especially the light colored clays have undoubtedly been derived from these drifts.

The southeastern part of the State is spoken of as the Loess Area because of this light colored soil.

ARCHÆOLOGY.

That Dearborn County was inhabited by a race of people before the Indians came is evidenced by the mounds located within and near its borders. One is located on the ridge south of Guilford overlooking the Tanner's Creek valley. This mound has never been opened. Another is on the ridge on the north side of North Hogan Creek, one and one-half miles north of Moores Hill. It is about thirty feet in diameter and six feet high. It was opened by a party from Moores Hill College but nothing was found. Just over the state line in Ohio is a mound ten feet high and twenty-five feet in diameter. This has not been opened. The most prominent mound is on the eastern side of the Miami River, overlooking the B. & O. S. W. R. R., not far from the Miami River railroad bridge. The hill on which it is located is called Fort Hill.

The view from this place is most picturesque. The panorama that stretches out before one lies in three states—Ohio, Kentucky, and Indiana. Those who chose this site must have had some love of nature, but this was evidently not the real reason. To them, protection from their enemies, was without doubt the true purpose. This is not a conical mound but it is built like a fort. It consists of a ridge of earth on the top of the hill where the slope down to the Ohio Miami valleys is very steep, thus insuring good protection. The earthwork is still from six to eight feet in height, and incloses about twenty acres. On the eastern side is a gateway.

Near Aurora there are several small mounds, and one was within the city limits but it has been removed. Some thirty years ago, a mound was opened near the mouth of Laughery, 100 feet in diamater and fifteen feet high. In it was found an earthen pot with some fragments and also some human bones.

Near the Ohio state line a number of human skeletons were found where some men were excavating for the foundation of a barn. The skeletons were lying at intervals of about thirty inches, with their heads toward the west, facing the east. Nearby other skeletons have been found. On the bottoms, as far as Aurora, skeletons have been found, thus indicating that there must have been a rather dense population.

These were the people commonly called Mound Builders. Who they were is not certainly known. The Indians never seemed to have lived in the bottoms but would come there on their hunting or warring expeditions.

Relics of various kinds have been found in different parts of the county. Many different kinds of arrow points occur. In fact, these constitute the chief relics. Where these occur there are indications of a camp or village. These flints have been made from the quartz rocks that occur in some localities.

Mr. George W. Turner, a prominent farmer near Moores Hill, formerly Recorder of Dearborn County, has been a collector nearly all his life. He has probably done more work in this line than any other man in the county. I here give a brief summary of his work as a collector. He reports as follows:

"I have about 2,000 specimens in my collection of Indian relics. Out of this number about 900 specimens have been found in Dearborn County, namely: arrow points, one-half inch to seven and one-half inches in length; spears, flint-knives, three and one-half to six inches; spades, five to ten and one-half inches long; celts and axes, grooved and ungrooved; slate ornaments; pipes, pottery, flint drills, and many other articles of unknown use. In August, 1898, we opened a mound on Orchard Knob in Lawrenceburg Township, this county. From this mound I found one Copper Drill, one Breast-plate, one South Sea Island shell, and many other articles. In 1897, the same workmen, while removing a gravel bank on the Tebbs farm near Lawrenceburg, Indiana, unearthed forty-two fine notched leaf-shaped flint implements from a cache, two feet square, which I now have in my collection".

The mastodon of the Pleisotcene period must have roamed down the Ohio and Miami Valleys for parts of their skeletons have been found. On the bottoms above Lawrenceburg, a part of the osinnominatum was found well preserved, and is now in the Museum of Moores Hill College. At Big Bone Lick, in Kentucky, the skeletons of many mastodons have been taken, so it seems that this entire region must have been the homes or at least the feeding grounds of these wonderfully interesting animals of the ancient times.

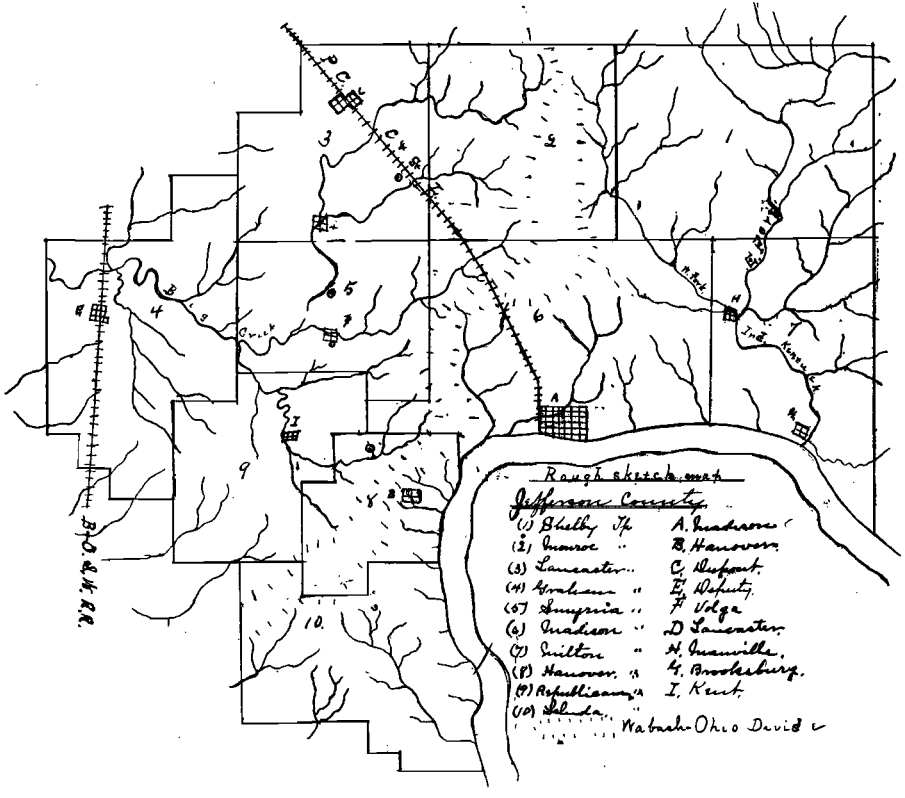
The Geology and Natural Resources of Jefferson County.

By Prof. Glenn Culbertson, Hanover College.

The key to the topography and drainage of Jefferson County is in the location of the Wabash-Ohio Divide. This divide extends from Saluda Township in the south through Hanover, Madison, and Monroe to the Ripley County line. Its altitude is approximately 875 feet above sea level, and some 400 feet above the low water mark of the Ohio River. All the streams to the east of the divide flow directly into the Ohio. They are Indian Kentuck and its leading tributaries, Lost Fork, Doe Run, Dry, Brushy, East, Seal's, Wilson's, and West Forks, Toddy's Branch and Wolf Run, and Bee Camp, Crooked, Clifty, Saluda, and the headwaters of Fourteen Mile creeks. Since the divide, as at Hanover is only one and a half miles from the Ohio River, and at the farthest only twelve or fifteen miles, all of these streams have a high gradient. Those with the shorter courses have deep ravines and picturesque falls, as Clifty, Deadman, Crowe, Butler, Chain Mill, and Hearts, over which the water plunges to the depth of from forty to a hundred feet.

The sides of these ravines have slopes of from 25 to 35 degrees near the Ohio, and from that to the vertical, just below the falls. One of the interesting features of the slopes in the valleys and ravines, extending approximately east and west, is, that those facing the North are perceptibly steeper than those facing the South. The north slopes in almost every case, are from two to four degrees the more precipitous. The more rapid creep of the soils of the south slopes, because of the more frequent freezings and thawings during the winter season is probably sufficient to account for the difference in gradient of the two slopes.

The main tributaries of Indian Kentuck creek, meeting with less resistant rocks, in their development have extended their heads back some 30 miles from the Ohio into Ripley County. The lower portions of this stream, with its tributaries, drain the eastern part of the county, including Milton, Shelby, and the


P. C. & St. L. R.R.
B. & O. & M. R.R.
Rough sketch map
Jefferson County.
(1) Shelby Tp.
(2) Monroe "
(3) Lancaster "
(4) Madison "
(5) Smyrna "
(6) Madison "
(7) Smilton "
(8) Hanover "
(9) Republicanville "
(10) Salida "
A. Madison
B. Hanover
C. Milford
D. Lancaster
E. Defiance
F. Volga
G. Jeffersonville
H. Jeffersonville
I. Kent
Wabash-Ohio Divide

eastern portions of Madison and Monroe Townships. Indian Kentuck has cut its bed to the temporary base level of the Ohio River. So much of it has reached this level, in fact, that in case of floods in the larger stream, the backwaters extend up the valley of the smaller to the distance of more than five miles. As the hill tops of the eastern portion of the county have approximately the same elevation as those of the central part, the valleys are very deep with decidedly precipitous slopes. In general, the crests of the higher hills and ridges on the Ohio side of the divide are from 350 to 425 feet above the level of the Ohio and the deeper valleys. The topography as a consequence, is extremely rough, and has a marked influence on the character of the agricultural pursuits. The southwestern portion of the county, including some of Saluda township, which is drained by the headwaters of Fourteen Mile creek, has a topography much less rough.

The streams of the Wabash side of the divide, largely tributaries of Big creek, whose waters flow into the Muscatatuck and thence to the east fork of the White River, have a course approximately of 250 or 300 miles before reaching the level of the Ohio River. The slopes therefore, of the westerly flowing streams are comparatively gentle. Big creek and some of its tributaries, especially where the direction of the flow is approximately parallel to the dip of the rocks through which the streams have cut, are noted for their numerous meanders or curves. These have in many cases almost vertical limestone cliffs, some of which reach to the height of 70 or 80 feet on the convex side, and long gentle slopes on the concave side.

The surface of the main divide is extremely flat. To the west, on the Wabash side of the divide, the topography is largely gently rolling. On the divides, between the streams, are some flat areas, the remnants of an old glacial peneplane. The highest hills in the west do not rise more than 100 feet above the stream beds.

The beds of the easterly flowing streams contain great quantities of thin, flat limestones, derived from the limestone layers of the Lorraine of the middle Ordovician. The westerly flowing streams are cutting out their valleys from the Niagara and Devonian limestones, consequently, their stream beds are largely in the solid rock. The slope of the stream beds in the west is very nearly that of the dip of the rocks. Not infrequently, large blocks of limestone fall from the cliffs to the bed of the stream below.

The outcropping formations which to a large extent, have

controlled in the formation of the topography, drainage, and the soils of Jefferson County are very interesting. In parts of the county, as in Hanover Township, where the Wabash-Ohio divide approaches more closely to the Ohio River, the outcropping rocks of the Lorraine and Madison beds of the Ordovician, the Clinton and the Niagara limestones and shales of the Silurian, and the Corniferous limestones and the New Albany Black shale of the Devonian formations, are all found within a distance of three miles.

The outcropping ledges of the Clinton and the Bluff or Laurel limestone of the Niagara, have largely controlled in the development of the topography of Jefferson County. These rocks may be seen along the crest of the river hills in the south, and along the hilltops to the west of the basin of Indian Kentuck creek, in the central and northern portions of the county. These outcropping ledges are everywhere, just to the east of the main divide. The formations in the central and eastern part of the county dip some twelve or fifteen feet to the mile towards the southwest; those in the western part proabably dip slightly more in the same direction.

The hilltops in the east are capped with the dirty grey or yellowish argillaceous limestones of the Madison beds of the Ordovician. This limestone, which forms the upper part of the Richmond, and named the Madison beds by Foerste, is some 40 to 60 feet in thickness, and is usually quite soft below and very much more resistant above, within 15 feet of the Clinton layer. The streams of this eastern part of the county have cut to the depth of some 300 feet into the alternating and easily eroded blue shales and thin limestones of the Lorraine.

The rate of eroison in the valleys in the case of many of the easterly flowing streams, where the gradients are very steep, is very rapid. The downcutting in some of these valleys, during the last fifty years, since the practical disappearance of the forests, has probably exceeded that of any previous period, ten or twenty times as long.

The Clinton limestone, generally of a salmon yellow color, and abundantly fossiliferous, is a thin layer seldom more than three and a half or four feet in thickness. It outcrops near the tops of the river hills in Saluda, Hanover, and Madison Townships, and in a similar position along the crooked creek, Wolf Run and West Fork hills in east Madison and Monroe, and in many places near the hilltops in Shelby. It is probably the most

resistant rock of the whole series because of its close crystalline texture. It is one of the principal resistant strata in the development of the numerous falls. This formation is found capping the rocks in the stream beds above the larger falls, as at Butler, or else it ouctrops in the stream bed a short distance above, in the valleys of the easterly flowing streams. In no case have the westerly flowing streams reached the Clinton formation in their downcutting. On the hill slopes the Clinton frequently projects as a small cliff or rock terrace.

Many of the springs in the river hills flow out just above the Clinton layer, as for instance, at the watering troughs on the Hanover, Graham, Canaan, Michigan, and Ryker's Ridge pikes. The location of so many of these springs at the outcropping edge of the Clinton layer is probably not so much due to the impervious character of the Clinton limestone as it is to a layer of soft shale one or two feet thick at the top of the Richmond, immediately below it.

The Clinton is separated from the Bluff limestone of the Niagara in many places by a layer of from ten to twenty feet of bluish shale, usually known as the Osgood shale, containing considerable chert and hornstone. The Bluff or Cliff limestone is the most noticeable formation of the whole series in Jefferson County. It is a hard, gray, resistant limestone, some 20 to 50 feet thick, capping many of the river and creek hills where it frequently forms a perpendicular cliff. Many of the hill slopes and stream beds in the same part of the county have great blocks of this stone scattered over them. These scattered blocks as well as the cliffs themselves covered as they frequently are, with lichens-mosses, ferms, and various flowering plants, add greatly to the beauty and attractiveness of the hills.

Above the cliff, limestone in parts of the county are out, croppings of the Waldron shale. The most important of these and the ones most abundantly filled with fossils, may be found along the banks of Little Graham creek, only a few feet above the water level, and within 15 or 20 yards of the B. & O. S. W. R. R. track, a short distance south of Paris Crossing or about one and one-fourth miles north of Deputy. Other outcrops occur along Big creek, some two miles east of Dupont, along the roadway near the bridge over Saluda creek, a short distance south of the High School building, and another near the Hanover School building.

The Corniferous limestone and the New Albany Black Shale

of the Devonian formations underlie the soil, and outcrop along the streams, of the greater portion of the county, west of the Wabash-Ohio divide. The thickness and character of the Corniferous limestone varies considerably in the different parts of the county. In thickness it runs from 30 to 50 feet. In places it has a dark bule color, but is usually a gray, varying from dark to light. The Black shale or Black slate as it is locally called, covers the higher lands west and in the midst of the Corniferous outcrops, but being easily weathered and eroded, it is not so frequently exposed as the limestone. E. R. Cumings, of Indiana Univeristy, in the thirty-second Annual Report of the Geology and Natural Resources of Indiana, in his discussion of the "Stratigraphy and Paleontology of the Cincinnati Series in Indiana," and August F. Foerste, of Dayton, Ohio, in the Twenty-first Annual Report, in his article on the Geology of the Middle and Upper Silurian Rocks", have given full descriptions and numerous sections of the rocks of this county from the lowest exposures of the Ordovician shales through the upper Ordovician, and Silurian.

The Mantle rock of the county is of three main types, depending on its origin. The flood plains of the Ohio, both first and second bottoms, or the flood plain proper and the first terrace, and the bottom lands of Indian Kentuck creek, are of alluvial origin. In these alluvial materials, however, there are in places great quantities of river worn glacial gravel and sand. The city of Madison is largely built on one of these glacial gravel deposits, and these deposits may be seen exposed in places in the lowlands in the upper part of the city, and along the banks of Crooked creek, both above and below the fill of the Pennsylvania Railroad. In many places the gravel and rounded pebbles of this fluvuie-glacial deposit, have been converted into a conglomerate by the cementing actions of waters, strongly impregnated with calcium carbonate. In the valley of Indian Kentuck creek, at a distance of a half mile or more from the Ohio, are deposits of several feet in thickness, very closely approaching in character that of the loess. This deposit was very probably made in the backwaters of the Ohio, turbid with the very fine deposits of the Champlain period. The alluvio-glacial deposits of the Ohio and Indian Kentuck creeks, are probably in no place in Jefferson County more than 40 or 50 feet in depth, since the former stream in places, as at the Hanover landing, is eroding in original rock and not in alluvial formations.

The Mantle rock of the steep slopes of the hills east of the

Wabash-Ohio divide, is very thin. This is especially true of the cleared land. It is formed directly by the weathering of the soft Ordovician shale and limestone, and is composed of soil and subsoil, rich in lime, and of thin limestones, derived from the Lorraine beds. The mantle rock of the very few small areas of level land, east of the divide, is derived from the formations above the Clinton beds. The rolling land of the western part of the county is covered with an mantle derived very largely from the Black shales, and of limestone and shale, derived from the Devonian and the Niagara. Where the Mantle rock has been derived from the limestones there is found much chert and other materials of silicious composition. This material makes up the larger proportion of the creek gravels of the westerly flowing streams.

The third main type of mantle rock is found on the flats of the Wabash-Ohio divide, and in part, extends over the higher ridges of approximately the same level on either side. In many places on the "flats" the mantle is 25 or 30 feet in depth, and is largely a glacial deposit. In gullies by the roadside or in old fields, striated, or glacially ground, pebbles and boulders may be obtained. Erratics weighing several hundreds of pounds, have, been taken from excavations, 15 and 20 feet in depth. As could be expected, however, the glacial material of this region is very largely derived from the sedimentary rocks nearby or to the north. The proportion of igneous rocks from the Canadian region is very small. In composition, therefore, this glacial mantle rock differs very litte from those formed *in situ*, from different varieties of sedimentary rocks.

Several of the geological formations of Jefferson County are very rich in fossils. So marked is this fact, that geologists and others, frequently visit Madison and vicinity for the purpose of collecting the abundant and widely distributed fossil fauna of the Ordovician. Here are found several hundreds of species of many types of invertebrate fossils, the most abundant of which are the, corals, bryozoans, brachiopods, and gasteropods. The already mentioned recent article by E. R. Cumimgs, in which the Ordovician formations, both as to stratigraphy and paleonthology, are so fully treated, makes it unnecessary to treat of these topics in this brief discussion.

In the article by A. F. Foerste in the Twenty-eighth Report, he treats rather fully the paleontology of the Clinton and the Niagara formation of the Silurian, in this and adjoining counties. The most interesting fossil beds of these formations are the cystidean

beds, which outcrop along the bed of Big creek in Monroe Township from the point where the Shun pike crosses that stream to a distance of some two miles above. These beds, discovered and worked by J. F. Hammell, of Madison, have furnished many rather rare and valuable species. Other interesting fossiliferous outcrops are those of the Waldron shales, above mentioned.

In the Twenty-sixth Annual Report, Edward M. Kindle treats in a similar manner the Devonian formations of this and adjoining counties, in his article on the "Devonian Fossils and Stratigraphy of Indiana." In passing, it may be added that the base of the Devonian in many parts of Jefferson County, but especially in the bed of Big Spring creek, some three miles southwest of Hanover, and along the roadside in the northwestern part of Hanover, and to the distance of several miles to the north of these localities, may be recognized by a coral reef formation, which is fully as interesting from the standpoint of numbers and size of species represented, and of structure, as that at the Falls of the Ohio. In addition to the fossil fish teeth mentioned by Kindle, as occurring in the Sellersburg beds, occurring just below the Black shale an almost perfect specimen of fossil fish head, some 8 or 9 inches long and 5 or 6 inches wide, has recently been obtained from a quarry in these beds at Big Springs. Several plant fossils have been obtained by the writer from the New Albany Black shale, which, so far as known, have not been mentioned by others.

In geological economic products, Jefferson County does not take a prominent place. The only important one, so far as known at present, is the soil, upon which the progress and prosperity of the county so much depends. Jefferson is essentially an agricultural county and upon agriculture its inhabitants must very largely rely. The most important topics to be discussed in the interests of its people, must be the soil, its origin, its composition and texture, and the methods by which it may be improved.

According to the Indiana soil survey (see Thirty-second Annual Report of Geology and Natural Resources), Jefferson County has five different types or general classes of soils. The writer of the present article, however, prefers to treat the subject of soils in a somewhat different manner.

Along the Ohio River and Indian Kentuck and Big creeks, there are what are locally known as bottoms or bottom soils. These may be further classified as first and second bottom soils. There is no distinct line of demarcation between the two, yet there is a difference in texture and subsoil. The real second bottom, or

first terrace, is not overflowed and was not even, by the great flood of 1884. The first bottoms are very largely overflowed, year by year. While the second bottoms are not extensive in Jefferson County because of the great curve of the Ohio to the west, leaving but small areas of lowlands on the convex side, yet there are very valuable areas. Above Brooksburg, in the eastern part of the county, these bottoms are, in places, very sandy, and in all places where they occur the soils contain more sand and gravel than is found in the ordinary first bottoms. Watermelons are grown, more or less, extensively and with considerable profit, on the sandy second bottom soils. The first bottoms are of a darker color and have a greater percentage of clay. It is a question whether the deposits left by the Ohio River floods of today are of any considerable benefit in adding fertility. So much of the material of these recent deposits come from worn out and gullied clay soils, that on the whole, not nearly so much fertility is left as in the past, when only the black loams of extended woodlands were eroded and deposited. The soil of the Ohio, and Indian Kentuck bottoms are largely alluvial, while those of the other streams are in many cases, largely colluvial, that is, their origin is largely from the hill slopes nearby. With the clearing of the steep slopes along the streams on the Ohio side of the divide, and with the resultant large increase in the volume of floods, the value of the narrower bottoms is rapidly deteriorating, because of the loss of soil and its replacement by gravel and small stones. All the bottom lands of the county are still largely planted in corn, although, in recent years, a considerable area has been sown to alfalfa. This has proven a profitable crop.

The soils classified on the soil map as Limestone Upland, extending over the greater part of the east half of the county, may well be classified under two heads. The first of these comprise the soils of the slopes of the more or less rugged hill lands. These soils are colluvial, but are composed almost entirely of the decomposed Ordovician shales and limestones, and in the most easterly part of the Lorraine, shales alone. These well drained, loose, fertile, and easily cutlivated soils, black with humus, proved very attractive to the early settlers in this part of the state. These rugged hill slopes were cleared and cropped, year after year, while the flat soils of the uplands were untouched. The result was an almost complete loss of soils from these hills, and in the case of hundreds of acres, a complete abandonment. As man gave up the attempt to earn a living on them, nature again began

her work and is clothing the hills with shrubs and trees, among which are the valuable Black Locust. A decade or so ago, some one wiser than this neighbors, sowed a few acres of these steep, and rocky limestone soils in sweet clover, and the effect has been far-reaching. The seeds of the sweet clover have been carried by the streams, and borne by animals, including man, to thousands of acres of this land. Large areas of what, a few years ago was considered worthless soil, has been redeemed and made fertile. The growth of the sweet clover with its deeply penetrating root system holds the soil and at the same time adds nitrogen and humus. It prepares the soil for blue grass and alfalfa. It furnishes excellent pasture for cattle, and is valued very highly by the apiarist, as the abundant source of a high quality of honey. With the increased growth of alfalfa for winter feed, and of sweet clover and blue grass for summer pasture, there is a bright future for the erstwhile worthless limestone hill lands of much of southeastern Indiana.

The soils of the uplands, or comparatively level portions of the Ohio side of the divide, are in the main good, and on them are some of the best farms of the county. The great need of these soils, as they are farmed, as well as of 90 per cent of all the farms of Jefferson County, is humus. Too continuous cultivation of corn, wheat, hay or other crop, without barnyard manure, clover, or other humus adding material, has reduced productiveness to one half what it should be. Commercial fertilizer, to the neglect of the humus supply has impoverished many a farm in Jefferson County, and tens of thousands in southeastern Indiana.

The area included in the soil map of the Thirty-second Report, as Volusia silt loam, and which covers the greater part of the county, west of the divides, varies considerably in texture and fertility. This in the writer's opinion, seems to depend on the depth of the soil above the limestone substratum. The quality of the soil, and the value of the farming lands in much of the northeastern and eastern part of the Volusia silt loam area greatly exceeds much of that in the southerly and southwesterly part. The former are, in part, formed from the decomposition of limestones, or have had much calcareous material brought to the surface through capillary action. The broad valleys, even in the western part of the county, where the soil rests on a substratum of limestone, as along Big Spring creek and other streams farther west, are much more fertile. In much of the region in the west, as in parts of Republican Township, where almost all of the soil

has come from the weathering of the Black shale, and where it is underlain by considerable depths of the same rock, the soil is heavy and very soon loses its fertility by continuous cropping. On these soils the principal plants, growing in old wornout fields, are the sassafras, greenbriar, dewbriar, and low scraggly growths of the blackberry. The greater part of the uplands in the Volusia area, as well as those included in the Miami and Scottsburg Silt loams, are not only greatly in need of humus, but especially of lime. Those limited areas of soils that are immediately below, or that are above but within a few feet of the outcropping limestones, probably do not need lime. The secret of successful farming over the rolling lands of the western part of the county, lies in the addition of lime in some form, and the periodic growing of crops or other treatment to keep up an abundant supply of humus. The addition of fertilizers should have double the effect, when these soils are properly amended so that their texture shall be greatly improved.

The soils of the "Flats", "Slashes", "Buttermilk", or "Crawfish" lands, as they are variously called, comprise the remaining portion of the county. They are largely the Miami and Scottsburg silt loams, of the soil map, but are more widely distributed in smaller areas, especially in Madison, Smyrna, Hanover, and Republican Townships. These flat areas are probably the remnants of a much more extensive glacial penoplane, which has since the disappearance of the glacier, been dissected by the erosive work of streams. The soil proper, of all these areas of flats, is extremely fine grained, and of light color. The grayish or bluish-white color, is probably due to the long continued action of swamp waters, containing carbon dioxide, and humous acids, on the iron oxide, and hence causing in large part, the removal of the coloring matter. The decaying vegetation in the woodlands of these flats, not infrequently after heavy rains, color the streams draining them to a chocolate brown. The difference in fertility between the soils of the flats in the western part of the county, or the Scottsburg silt loams, and those in the central part or the Miami silt loams, where this is at all marked in favor of the latter, is probably due to the sources of the materials transported by the glaciers in their formation. Those of the westerly area had their source from the outcrops of the Black shale, while those of the central part, largely from outcropping limestones, and of soils of limestone origin.

Viewed from the farmer standpoint, these flat soils upon which

the Sweet Gum, Black Gum, Beech, and Black Jack oak grow, are difficult to work. They are very heavy and cold, and during wet seasons, crops are frequently a total failure. Where handled wisely, however, these soils are proving more and more valuable. In dealing with them the first important point is thorough drainage. For surface drainage the fields are plowed in narrow strips 25 or 30 feet between the dead furrows, which are deep and kept open at the ends that the drainage may be unobstructed.

Because of a hardpan, or a very close textured impervious layer, which is often found a few feet below the surface, and which does not permit the ready escape of the water downward, many farmers cultivating these soils are of the opinion that tile drainage would prove to be useless. Others, however, do not concur in that belief. What is needed, above everything else in connection with the flat lands of this and adjoining counties, is a thoroughly reliable tile drainage test on some ten or fifteen acres of the worst hard pan soil. With successful drainage, deeper plowing, lime and the ever needed humus, these soils should prove among the best.

Stone, although so abundant in the greater part of Jefferson County, is rearly found of high quality, for construction work. A few feet of the Laurel limestone of the Silurian, as at Hanover and along Big and Middlefork creeks in the northern part of the county, is a rather valuable building stone, and has been used by the Pennsylvania Railroad for bridge and culvert construction, and rather extensively for foundation work. Portland cement has largely superseded the use of such stone for construction purposes. The chief value of stone in this county today, is for agricultural, road building, and concrete purposes. In the Thirtieth Annual Report of Geology and Natural Resources, is given a discussion of the quality, and distribution of the road materials of this county. In this connection, however, it may be said that in the building and repairing of macadam roads in this county and probably in many others, very little attention is given to the quality of the stone. The specifications for new roads call for crushed stone so many feet wide, and so many inches deep and of a certain size, but a special examination, and testing of materials to be used, a point of very great importance in building a first class, and lasting road, is seldom, if ever, made by an expert. Soft rocks, long exposed to weathering, and already crumbling, together with much soft shale and clay, are hauled out for repair work or for the making of new roads. The life

of such materials is at the longest, but a year or so. The cost would be but little more were good materials specified and demanded in all road contracts. The taxpayers are paying for good materials and those in authority should see to it that such materials and only such materials are used.

Recently, several plants have purchased and erected for the purpose of pulverizing limestone for use on farms for amending the soil. Such plants have been pulverizing limestones in Hanover, Graham, Madison, and Monroe Townships. The stone used in the first two localities is a high grade Devonian limestone analyzing above 95 per cent lime. The Niagara limestone, outcropping in Saluda, Hanover, Madison, Monroe, Lancaster, and Symrna Townships, is used in other places, and the better grades are probably equally as good as the Devonian, of the western part of the county. The clay limestones of the lower Madison beds, and the Lorraine, of the eastern part of the county, are not usually of a quality to be of value for pulverizing.

Another economic product of Jefferson County, while not of great importance at present, is yet of considerable popular and scientific interest. This is the natural gas obtained during the last half dozen years, from three wells driven for water. The first of these was driven in March, 1908, on the farm of Mr. William Rowlison, two miles north of Volga, in Symrna Township. The writer visited this well soon after gas was found, and quite a flow of gas was escaping through the water in the bottom of the well. Owing to the inability of the owner to have the well properly packed at that time the correct gas pressure could not be obtained. Later the well was packed and the gas piped to the owners residence nearby, where it has been used for fuel, for cooking and heating, and lighting purposes for the last 6 years, with small reduction of pressure. The second well was bored near the residence of Mr. Theodore Schneider, one and one half miles northwest of the town of Hanover. Gas was struck at a depth of 85 feet, and the pressure, on packing the well several weeks afterwards, was found to be approximately 70 lbs. to the inch. This gas was used for household purposes for some four years and a smaller flow still continues. Gas was obtained at about the same time in a driven well at Volga, but no use was made of it. The last well drilled in which gas was obtained, was on the farm of Mr. W. R. Dryden, a few hundred yards south of Middlefork station of the Madison branch of the Pennsylvania Railroad. Gas was struck here at a depth of 168 feet, and the

pressure on packing the well a few days later was between 90 and 100 lbs. This gas was piped to the residence a few hundred of feet away, and has been used for heating and lighting purposes for the last two years. The pressure is still almost as strong as when the gas was first obtained.

In the case of the Schneider well, no record was kept of the thickness or character of the strata, passed through in drilling, but so far as may be judged from the prevailing thickness of the strata in the vicinity, the gas in this well was struck near the horizon of the upper Madison beds of the Ordovician. At the Dryden well, farthest north, gas was obtained at a depth of about 150 feet below the coral reef layer of the lower Devonian. This would probably be some 60 to 75 feet below the Clinton layer, and would reach the lower Richmond beds. The depth of the Rowlison well is reported as 167 feet, and if that be correct, the gas here was obtained at approximately the same horizon. These wells are found within an area, nine miles long and two miles wide. Whether other wells would strike gas within the same area is an open question.

It is the popular opinion through this region, that this gas originated in, or has some connection with the Trenton limestone. This, in all probability, is an erroneous conclusion, since it is not at all likely that gas from the Trenton limestone could pass through the hundreds of feet of the Ordevician shales and be obtained in these upper rocks. Mr. Frank Oliver, of Dupont, owner of a well-boring outfit, during the season of 1915, sank a well to the depth of 1,000 feet, on a farm only one-third of a mile north of the Dryden well with the expectation of obtaining gas from the Trenton limestone. He was disappointed, as no gas was obtained from any source. Other borings in Jefferson County in the past have penetrated the Trenton limestone but without obtaining gas. It is not at all likely that any great quantity of gas will ever be obtained from the rocks underlying this county, yet enough may be obtained to make it profitable to use for household purposes over a limited area.

With a good market for an electric current, water power plants in such streams as Clifty, and perhaps others, may be profitably located. With the building at Clifty of a series of large reservoirs at a distance above the falls for the purpose of impounding the waters of excessive rains, and then piping it for some distance along the bluffs below the falls, a drop of 175 or 200 feet

could be obtained. Such a plant on this, and similar plants on other streams, are among the possibilities of the future.

From the stream beds of the southwestern portion of the county, some gold has been obtained. One man with shovel and pan is said to have earned from a dollar to a dollar and a half a day for several weeks in washing the sands in the crevices of the rocky creek beds. The very small quantity of gold found in these streams is of glacial origin, and has been brought in from regions far to the north. Black sand, the usual accompaniment of placer gold, may be seen along almost any road side gulley of the county, but gold in paying quantities will not be obtained in this region of sedimentary rocks.

In scenes of great natural beauty, Jefferson County is unexcelled in the state, if indeed in the Mississippi valley. The gorge of the Ohio, reaching its greatest depth, where this stream cuts through the resistant Silurian strata in the vicinity of Hanover and Madison, presents views of unusual interest and attractiveness. These river views, as beheld from the top of precipitous bluffs, as Cedar Cliff and Cragment on the east, and College and Logans Points on the south are without superiors of their kind in any region. At the heads of half a score of deep wooded ravines in the same locality are picturesque falls and rapids. The principal ones of these, beginning with that of Clifty creek on the north, are Clifty, two miles northwest of Madison; Deadman and several others at the head of Happy Valley, one-half mile northeast of Hanover; Crowe, within the town of Hanover; the two at the head of Butler Ravine and Chain Mill, one-half and one mile south of Hanover, respectively; with heart's and the rapids and falls of Saluda creek, three and five miles south of the same point. Over precipices, varying in height up to 100 feet, and through gorges of much greater vertical dimensions, the waters of these streams plunge in their brief course from the Wabash-Ohio divide to the valley of Ohio, 400 feet below.

The ever invigorating atmosphere of these hills, and the great natural beauty of the whole region, attracts many, and should attract many more visitors, for health and pleasure. No part of our esteemed commonwealth furnishes a better opportunity for the student, whether of rocks and their contents, of plants, of birds, and insect life, and of nature in all its varied forms, than do the valleys of the Ohio and its tributaries in Jefferson County. The outcropping ledges and abundant fossils of many formations,

the hills and valleys, the deep ravines, the cataracts and rapids make geology a study of ever increasing interest and pleasure. The varied flora and fauna of the deep Ohio valley and wooded ravines, of the hill slopes, and of the level and more or less swampy lands of the "Flats", give abundant material for the botanist, entomologist, and bird lover.

Among objects of archaeological interest, very little remains. Of the series of watch towers, or signal stations along the bluffs of the Ohio River used by prehistoric peoples, nothing is left. Of the very interesting old fort on the triangular point of land between the cliffs and precipitous slopes of Big creek on one side and of the former course of Little Graham creek on the other, lying just west of the water tank on the B. & O. S. W. Railroad, a mile north of Deputy, a few scattered stones, marking the site of the wall of defense on the land side, and the topography of the site, alone remain. A few years ago, under the auspices of Miss D. L. Cravens of Madison, the writer examined a number of supposed and real prehistoric mounds, and superintended the opening of some that had not at that time been fully excavated. The supposed mound within the town of Lancaster, and the one a short distance north of Middlefork station were found to be elevations, due to natural causes. The Lawson mound, about one mile east of Manville, on the high narrow ridge between Indian Kentuck and its tributary, Brushy Fork creek, was in part excavated, and in addition to a few flint implements, a very interesting bit of old pottery, and a few of the larger bones of two badly decomposed skeletons were obtained. The earthenware vessel is of about five or six quarts capacity, and contained, when found, the remains of two or three mussel shells. The articles found in this mound are now in the museum of Hanover College. The Walker mound, located in the valley of the Ohio, near Hanover, was thoroughly examined. This mound had been excavated by parties many years ago, when a number of large copper beads were found. The later opening disclosed nothing further except another bead, now changed largely to the green copper carbonate, and a few implements.

At a point about one and one-half miles southeast of the Lawson mound, Mr. Fred Wolfe, a few years ago, inadvertently epened a burial ground, while grading and excavating a site near his residence for a farm building. He reports the finding of many badly decayed human bones together with their crude rock cover-

ings. A skull or two and some others of these relics of prehistoric peoples were preserved for a time by neighbors, it is said, but now probably nothing is now left. The old gravel bar, below the Hanover landing on the Ohio River, which is composed of rounded glacial pebbles, gravel and sand, was a site where the ancient inhabitants of this part of the Ohio valley, manufactured many stone implements, such as arrow and spear heads, axes, etc. Many of these interesting objects have been collected from this place in the past, and a few are still obtained.

Geology of Greene County.

W. B. VAN GORDER

Greene County is one of the largest counties in the State. It is bounded on the north by Clay and Owen Counties; on the east by Monroe and Lawrence Counties; on the south by Martin, Daviess and Knox Counties; and on the west by Sullivan County.

In shape the county approaches very closely the form of the rectangle, having a length of thirty miles, east and west, and a width of eighteen miles. However, from this rectangular shape there must be subtracted a strip nearly one-half mile in width and six miles long, from the south side of Stafford Township, which small strip is a part of Knox County. The county, therefore, comprises an area of about 534 square miles.

ELEVATION.

A corps of United States engineers, under the direction of the Coast and Geodetic Survey, during the years of 1906 and 1907, conducted a number of surveys for precise leveling. This portion of Indiana was included in these surveys. Beginning at Owensburg, in the southeastern corner of the county, it was found that the top of the rail in front of the railroad station was 642 feet above sea level. Three hundred forty-three feet west of the station on the overhead bridge, south side of the track, in the top of a coping stone is a tablet stamped 641 feet above seal level. Following the railroad west to Dresden, another point of elevation is established. Here in front of the station, the top of the rail was found to be 570 feet above sea level. At Robison, some two miles further up the track, at the highway bridge on the south side of the railroad track there is fixed in the east abutment, an aluminum tablet stamped 543, while the top of the rail in front of the railway station was 540 feet. Nearly three miles north of Robison and in Center Township, at the church of the "Later Day Saints" or the "Temple" is another marker which indicates that this place is 755 feet above ocean level. At Cincinnati, a village in Center Township, some three miles northeast of the

last named placed and in the front yard of Mr. J. H. Neals, the government placed an iron marker, such as is used where a rock surface is not at hand. On this marker is stamped, Prim. Trav. Sta. No. 7, 880. This point is nearly 200 feet higher than any elevation in the counties surrounding Greene, and is the highest place in Greene County. Taking up again the line of leveling along the Chicago, Indianapolis, and Louisville Railway, the next point is Koleen, and here the top of the rail in front of the station is 521 feet above the sea. Three hundred and seventy feet north of the station is an iron post stamped 519, 1906. Two miles more at a point locally called Rockwood, and at the crossing of the public highway, the top of the rail is 517 feet. At Mineral City an iron post is used to mark a spot which is .38 of a mile east of the station near the road crossing, and is 509 feet, while the top of the rail in front of the station is 508 feet. Again, two and one-half miles northwest of Mineral City, near the railroad track and at a private road is another iron post, marking the place at 509 feet.

Two points of level were established in Bloomfield. The first, 120 feet west of the Monon station, an iron post is marked 534 feet, 1906, and a second one, not far away from the first, is stamped 541, 1906. Following this quadrangle, as made by the U. S. engineers, and we find at Elliston at the top of the rail in front of the station to be 508 feet. A second point, one and three-fourths miles north of Elliston, has an elevation of 503 feet. A third station, four and seven-tenths miles north of Elliston, and near the railroad track has an elevation of 506 feet. The last three elevations follow the toe path of the old Wabash and Erie Canal, indicating the feasibility of this means of transportation in early days.

There are two elevations for Worthington, the top of the rail of the railroad in front of the station and the other an aluminum tablet set in the Taylor building. These points are 522 and 526 feet, respectively. These two markers are also close to the path of the old canal and the difference in the elevations of these two markers as here given, and the elevations of the other three along the old canal to Elliston, suggest the necessity of locks when the canal was built. The higher ground near Worthington was thus overcome and a lock was placed just outside of the corporation of that place. Three and two-tenths miles north of Worthington, near the Terre Haute and Evansville track is the last point of elevation determined along this line. It is also close to the

old canal bed and has an elevation of 520 feet. All of these markers, beginning with Elliston, are on the west side of White River and are a fair index of the height of the land in the western part of the county.

The first five elevations named in this report are in the southeastern part of the county and are along the valley of Plummer Creek and indicate not only the height of the land in this section, but the elevation of the land in all the valleys of the eastern part of the county. The elevation of 754 feet north of Robison and the point of 880 feet at Cincinnati in Center Township may be taken as indicating the land elevations outside of the valleys for the portion of the county lying east of White River.

White River flows across the county from north to south, dividing it into two equal portions, the part east of the river being a few square miles the larger. There is, however, a great difference in the surface of the two sections. That portion of the county west of the river is comparatively level, as before stated, and will average 500 feet in height, while the eastern part will average 200 feet higher. The eastern part is very much broken and with hills ranging from 100 to 300 or more feet in height.

Geological Formations.

The geological formations, which are here and follow each other in regular order, are the sub-carboniferous limestone period; the millstone grit period; coal measure epoch; and the glacial epoch. The sub-carboniferous limestone underlies the whole county. It is made up of a number of strata, differing in thickness, color, and texture. Lying in between the layers of limestone are beds of shales of a few inches in thickness up to several feet. These limestones and shales make up a rock bed of very great depth as shown from the borings of a number of wells that have been put down in the county by persons prospecting for gas and oil.

The upper surface of the carboniferous limestone crops out at a comparatively few places in the county. On the north side, where the Indianapolis and Vincennes railway enters the county, a small cut was made for the roadbed for a few hundred feet. This cut reaches down into the limestone. The upper surface of this limestone is covered with a few feet of mantle rock, made up largely of drift. The farm lands on either side of this railroad cut consists of a few fields of level surfacing, conforming to the horizontal rock strata which is only a few feet beneath the surface.

About 500 feet north of the county line is Fish Creek in Owen County. Here the limestone rock is exposed for some distance along the bluff bank of the creek, and has a thickness of 15 to 20 feet. The limestone at this place represents probably the best example of the Chester group in the county and the only place observed where the limestone is not overlain with sandstone.

As the sub-carboniferous limestone consists almost wholly of sea formations, the numerous fossils present in this are mainly marine, though at most any place of outcrop the rock is usually so worn that it is not always easy to find a sufficient number of specimens of any one kind to determine them. The following, however, were made out *Pentremites pyri formis*, Hall, *Archimedes Wortheni, Productus carbonarius*. There were also numerous *encrinite* stems.

Going now to the other side of the county, and two miles north of Ownesburg, in Jackson Township, and we find there another outcrop. The place is known as the Sexon spring. Here the limestone is exposed horizontally for 100 feet and to a depth of 10 to 20 feet. Above the limestone is a sandstone, the millstone grit. This sandstone has a thickness of 50 feet. At the base of the limestone is fragmentary rock or talus to a depth of 10 feet, and altogether presenting a wall some 80 feet high, a very imposing and beautiful spot. Just below the junction of the sandstone and limestone there gushes forth a stream of water, a spring. The water flows over and through the talus, and has a drop of some 10 feet, coming forth in a clear stream of pure rushing water, some 6 inches deep and 8 feet wide.

The grounds about this spring have been placed in good order. The rustic seats, amid the profusion of wild flowers, invites you, on a summer day, to spend a few hours at this ideal place. The public highway passes these grounds and Mr. and Mrs. Sexon, whose residence is only 100 yards away, have cared for these premises for the benefit of the public, and the enjoyment it gives the owners. A hydraulic pump, placed at the spring, supplies the house with water and stock at the barn. The limestone at this place is a hard, durable rock and of a slightly blue cast. It does not contain a great number of fossils. There were a few fossils, *Pustula, alternatus*, and a few *encrinite* stems seen.

A second outcrop of this limestone to be seen in Jackson Township is found one mile north of Dresden in Sec. 17, and on the farm of Mr. Frank Edington. The limestone is exposed for 50 feet horizontally and has a depth of some 10 feet. Below this,

limestone is a mass of rubbish rock or talus, which has covered up some of the limestone. Above the limestone is a layer of sandstone, 40 to 50 feet in thickness. This, as in the former case, presents a precipice of bold front 75 feet high. Overhanging this massick rock are a number of native forest trees. At the edge of this glen are other trees, which help to preserve the freshness and beauty of this spot. There is also at this place, a spring. At the junction of the sandstone and limestone there bubbles forth a bountiful supply of cool water. It finds its way down through the rubbish rock, a descent of about 8 feet, where it forms quite a rapid current about 5 inches deep and 6 feet wide.

A third outcrop of limestone to be described in Jackson Township is known as the "rock spring" near the public highway, a mile east of Koleen. Here the limestone is seen in width, about 50 feet and in depth, 15 feet. Above this limestone is a layer of sandstone, 35 or 40 feet in thickness. At the middle point of the exposed limestone and 15 feet below, where the sandstone joins the limestone, there is a large spring. At this spring there is no rubbish rock, the water flowing away at the surface of the ground has probably carried away all fragmentary material that has fallen from above. The water, instead of flowing away at the junction of the sandstone and limestone, has no doubt cut its way down through the limestone at some place back in its course. This is one of the beautiful spots along that public highway. There are trees enough to conceal the place when a slight turn in the road brings you squarely in front of a wall of almost perpendicular rock, nearly 60 feet in height. A stream of water, 6 inches deep and 6 feet wide, flows away from this spring. The fossils in this limestone consisted almost wholly of encrinite stems and of various sizes.

In the western part of Center Township there is an interesting development of this limestone at a place known as Ray's Cave. The cave is some 60 rods from the public highway. In the highway there is quite an exposure of sandstone. On leaving the highway for the cave, the slope of the land is toward the cave. When you have traveled half way down this slope to the cave and at a point some 75 feet below the level of the highway you have just left, there is a small outcrop of limestone. This outcrop is only 2 feet wide, 6 feet long and 18 inches in thickness. This is what is known as the third limestone and is a thin layer of the Chester group and is found near the tops of the hills, where found at all. It is found at a few other places in the vicinity of Cincin-

nati. The outcrop of the third limestone in the vicinity of Ray's Cave contained one good specimen of the fossil *Archimedes Wortheni*, and one *Pentremites pyriformis*.

Below this limestone is a shale of several feet in thickness and below this, other shales and sandstone, which may be observed on continuing your course down this incline. When you reach the cave you are at a point at least 175 feet below the level of the highway. Here, in a ravine, is the cave. Across this ravine is an outcrop of sandstone, 25 feet in thickness. Overlying this sandstone is a mantle of clay, 8 to 10 feet in thickness. Below this sandstone is a limestone, 6 feet in thickness. It is well filled with fossils. The fossil *Composita argentia* is most plentiful. Below this there is a thin layer of limestone, only 8 inches in thickness and quite distinct from the layer above. Below this there is another layer, 18 inches in thickness, followed by another limestone some 25 feet in thickness, and largely concealed by talus. Below this there is a shale, 2½ feet thick. Here we have a bold mural precipice, nearly 80 feet in height and about it a well wooded grove.

The Cave.

At the top of the layer of limestone mentioned as 25 feet in thickness is a cave. This cave is 10 to 12 feet wide on the floor and 8 to 10 feet wide on the sides. The roof slopes upward and at the entrance, and for some distance, at quite a sharp angle at the center or apex. This cave extends undergound for nearly a 1,000 feet and is quite uniform in structure throughout. You then reach a narrow point and crawling through this you may travel several hundred feet more. On the floor of the cave is a small stream of water about sufficient to cover the level floor. At the mouth of the cave the water trinkles down through some 30 feet of rubbish rock, where it forms a small inlet. It is simply a spring, the water having cut its way back through the limestone rock in the long ages of the past. The only form of life observed within the cave was a few specimens of the brown bat, *Myestis lucifugus*, clinging to the walls of the cave near the entrance.

There is a cave in Highland Township, known as Ooley's cave, which also may be traversed for several hundred feet. Sections of rock strata, similar to that observed at Ray's cave, was seen in the eastern part of Beech Creek Township. This lower limestone is to be seen only in such places as herein described and in deep ravines, though places of exposure are not many.

The most extensive outcrop of this carboniferous limestone noted, is in the northeast corner of Richland Township, Sec. 3. It is the bluff bank of Beech Creek, on the north side of the creek and on the farm of Mr. Jonathan Helms. This outcrop extends east and west for a distance of nearly one-half mile, and with the overlying sandstone, form a perpendicular and overhanging wall more than 100 feet high. At each end of this outcrop the rock, in ages past, has given away through weathering and now the land forms a gentle slope to the creek. The stratas of limestone here in color, hardness, and thickness, resemble closely that of Ray's cave which is only 3 miles away. There are a few other outcrops of limestone along Beech Creek, but all of them are small. *Pentremites pyriformis*, Hall, seemed to be the most common of the fossils seen here.

The term carboniferous limestone, has been used in a general sense and comprising the rocks of this formation below the coals. The carboniferous rocks are, however, made up of a number of strata that are sometimes difficult of separation and they do not always bear the same name,—such differences as is sometimes met with in botany and zoology, in the naming of plants and animals by different authorities.

This basic limestone, in order of formation or outcrop, is often called the first limestone. Overlying this limestone and resting upon it usually are many feet of shales and sometimes sandstones, as in the vicinity of Ray's cave, where nearly 100 feet of such material rests on this first limestone. The second limestone does not appear to be present at this place. However, the second limestone may be observed two miles west of Ray's cave, on Sec. 15, in the eastern part of Richland Township, on the bluff bank of a small brook and at the roadside. Here for several years,, the sandstone had been quarried for building purposes. After cutting down some 15 feet along this hillside, the limestone was encountered. The junction of the limestone and sandstone is 40 feet above the level of the land below. The limestone has now been cut down to a depth of 15 feet and 60 feet long. Resting on this limestone above is a sandstone, which not many feet back of this artificial outcrop must have had a thickness of at least 30 feet. This limestone itself seemed to be resting on sandstone below but this could not be determined on account of the rubbish rock that had been cast down the hill, nor could it be determined whether the exposed sandstone at each end of this fragmentary mass was in its native place, or had been moved down the hill.

It probably rests on sandstone as this rock and shales below this limestone may be observed in the public highway, a short distance to the south. This limestone is almost free of fossils. But one specimen was observed of *Pentremites pyriformis*, Hall, a few *encrinite* stems and one specimen of *Temnscheilus greenense*. This last specimen was identified by Prof. J. W. Beede, of Indiana University, who says that this fossil has been described by "Miller and Gurley" and from Greene County only. I am also indebted to Dr. Beede for identifying other fossils named in this report.

This second limestone at this place, at the time of observation, was being crushed for road purposes. It is first quarried and broken into pieces, 8 to 10 inches in diameter. It is then put through a machine which reduces it to small fragments, suitable for road ballast, in place of gravel which cannot be had here. The machine was crushing from 50 to 75 cubic yards a day. Mr. Edward Slinkard, road superintendent for the county, says that many miles of road in the eastern part of the county had been dressed with this material. It is a hard blue crystaline stone and durable. In a year or two this dressing forms a solid smooth surface. This stone is being quarried near Cincinnati, in Center Township, also at one place in Jackson Township, and at another in Taylor Township, and all for the purpose of supplying a road dressing.

Those first and second limestones, especially the first, are the water bearing stratas and are the sources of many springs that are to be found over this section of the county and these springs, in a number of places, have determined the location of homes.

A large artificial outcrop of limestone was made in constructing the Indianapolis and Southern R. R. from Richland creek to the county line. In a distance of 10 miles there are several deep and long cuts through this rock, showing the several stratas and formations.

Fossils.

In several outcrops the only fossil to be seen, in any abundance, was *encrinite* stems. At one outcrop in Jackson Township, the fossil, *Diaphragmus elegans* made up a large part of the rock. On Sec. 12, west end of Center Township, at a small outcrop, the fossils *Productus evatus, Productus sp. and Pustula sp.* were the forms most plentiful. At Ray's cave, *Pustula genevievensis* and *Spirifer leidyi* were of frequent occurrence.

The Millstone Grit.

This is the oldest name used in the State reports when speaking of this formation, though aware that two other later names have been used, we have thought it best to use the name "Millstone Grit." Following the subcarboniferous epoch in regular series is the epoch known as the millstone grit. This is a massive sandstone, overlying the subcarboniferous limestones. These two immense formations lie one above the other, though occasionally separated by a thin seam of coal No. 1, and shale. In the large development, along Beech Creek, in Richland Township, at the west end of this huge rock wall there is a thin seam of coal No. 1, a mere trace. Along the Indianapolis and Vincennes railway, a mile north and east of Worthington, the millstone grit and the carboniferous limestone are separated by 12 or 15 feet of shales. At the top of these shales is a thin seam of fire clay, and above this, a thin seam of No. 1 coal, 2 to 4 inches in thickness. Resting on the coal is the massive sandstone. These two great formations, limestone and sandstone, seem to separate as the sides of the angle between them lengthens in going from the east side of the county to the west, while the angle itself is occupied with shales and coal No. 1. The millstone grit is not always one compact structure; but it is generally in two rock masses, separated from each other by a thin seam of coal No. 2, or a seam of shale or both. The shale may vary up to several feet in thickness. These two rock masses have also an angle of separation, the sides of the angle growing farther apart as you go westward. This sandstone covers the entire portion of the county east of White River, also that portion lying between White and Eel Rivers, in Jefferson Township. The western boundary of this stone may be traced in an irregular line, across the county.

Beginning at Johnstown, in Jefferson Township, there is a small outcrop in the public highway. A mile south of this at the Watts coal mine it has disappeared. Not far north of Worthington, at what is known as "Ball Knob," there is another outcrop in the public highway. This rock is also to be noticed in the hillside nearby. Going southwestward of here, to Sec. 24 of Jefferson Township, and Sec. 23 of Smith Township, on the roadside in Smith Township, there is an outcrop. The sandstone at this place has been used for road and building purposes for a number of years. There is a mantle rock of clay, 4 feet deep and a wall of sandstone, mostly in layers, 14 feet deep. The surface

of the land, for a mile north and south of this point, abruptly slopes to the south, showing that this sandstone formation has disappeared. In a coal mine which enters the hillside, 200 feet south of this outcrop, there is a clay roof merging into shale and covering the coal to a depth of 10 feet. In two abandoned mines, 200 and 400 feet north of this outcrop of sandstone, the same conditions were found, marking off quite definitely for a considerable distance the western edge of the millstone grit. It is presumed that the sand stone overlying the shales at these coal mines had given away in past time and had disappeared. On sections 24, 25, and 36, in the southwest part of Jefferson Township, is a high ridge of land. The east side of this ridge forms the valley side of an ancient river bed. This ridge slopes to the west and marking here also the western edge of the sandstone. On the southwest corner of Sec. 36, in Jefferson Township, and the north corner of Sec. 1, in Fairplay Township roadside, and in the road on the hill, is an outcrop of this sandstone, the outcrop in the road making it difficult to travel. This is the southern end of the ridge just mentioned. Just over the fence of the roadside, at this place, is an abandoned coal mine. This mine had been worked for many years and hundreds of tons of coal taken out. The coal seam was 34 inches thick with a good sandstone roof. Below the coal were thin seams of fire clay and shales, as may be seen along the roadside nearby.

Taking now a southwest course of four miles and no more rock is met with until you reach the railway cut, one and a half miles west of Switz City. Here, a cut was made for the roadbed, 30 feet deep and several hundred feet long. This cut is through a hill, which exposed a kettle-shaped formation of sandstone, about 400 feet long. Below the sandstone is a shale which outcrops at each end of the cut. The dip of the strata is to the west. One mile and a half direct south of this railway cut, and where the public highway between Sections 28 and 33, in Grant Township intersect, there is a small outcrop of the millstone grit. The few coal mines, however, between the last two stations named along the roadside, have good slate roofs. Going one mile south we reach the corporation of Lyons. Many deep wells have been put down in this corporation, and in each case have encountered slate as the first rock, which is everywhere overlaid with 9 to 12 feet of clay. Southwest of Lyons in the railway cut of the I. and V. railroad, a cut of 35 feet deep, the only rock material met with, is slate and that near the bottom of the cut, the same

slate formation that is found beneath the corporation of Lyons. The next point where the sandstone appears is directly south of Lyons, in Sec. 29, in Washington Township. Here is a piece of land, known to the people of that community as "Dog Island". It consists of about 100 acres. It is only three-fourths of a mile from White River, and at times of high water, this land is entirely surrounded by water. Some 20 acres of this "island" is crowned with sandstone which is overlaid with 10 to 20 feet of mantle rock. This sandstone outcrops in the highway. There is, however, a large mass of this rock to be seen on the hillside in the field on the east side of the road, thus completing the irregular line across the county.

Between this line and the river, and extending from the south line of the county to Worthington, the country is almost one continuous valley from three to five miles in width, and the richest and finest of farming country. There is an outcrop of sandstone at the Hicks church in Washington Township, and at a few places along White River in this township, also at Elliston, in Fairplay Township, and at Worthington, for a mile along the valley side. So it may be said that White River flows across the county on the western rim of the millstone grit.

The portion of the county, east of White River, consists of about 280 square miles. It is on the whole, one immense rock. This pondorous massive sandstone, the millstone grit has been worn and blasted by the rains and frosts for ages, reducing this rock to its present form, and giving us the scenic beauty of the eastern part of the county. All the streams have cut deep and wide valleys, all the tributaries, creeks, and brooks have cut down to the main streams. Deep gullies and rocky hillsides abound everywhere. Angular and perpendicular rock walls are a feature of the valley sides. But few roads follow the section lines, and hence take the course of least resistance. Some of the main ones are ridge roads, while others are valley roads. This sand rock was examined at a great many places, and it is seemingly all of the same texture, color, and binding material. It has been quarried at many places for building foundations, now replaced by cement. Many fence posts have been split from this rock and are in use on several farms.

There are many places in this part of the country with a broad valley enclosed by encircling hills and studied with groves, a farm-house, fields of waving grain and running brooks, a landscape,

fit for the artists' brush, and as beautiful as is to be found in the state.

The Coal Measure Epoch.

This epoch often represents a rock formation of great depth. It is mainly a fresh water formation, in which stratas of shales and sandstones of various thickness usually predominate. The stratas alternate with seams of coal in no fixed order and indicate a rising and subsiding of the earth crust, covering a long period of time.

The coal of Greene County is found to be in six geological formations or numbers. The coal that is found on the east side of White River is coal No. 1 and No. 2. Coal of these formations is to be found at several places in Richland, Taylor, and Jackson Townships and of sufficient thickness to be mined for domestic purposes. It is usually a good black coal, Traces of coal No. 1. or in thin seams is to be found in Highland Township, along the bluff bank of the river. It is to be seen along the I. and V. railroad track, a mile northeast of Worthington, near the base of the bluff bank of the river. Coal No. 1 is found some three miles south of Worthington, on White River, at a point known as "Rock Ripple." When the river is low the coal can be mined at this place. The vein of coal is just under the water line and many tons have been dug out of the river, as told me by Mr. F. E. Dyer of Worthington.

Coal No. 1 lies near the limestone and coal No. 2 is found interlaced between the massive sandstones and ranges, 20 to 30 feet higher than coal No. 1. Along the western line of the sandstone outcrop in Jefferson Township, coal No. 2 is mined; also at the mines in eastern Smith Township and in the northwest corner of Fairplay Township. The seams of coal in these mines ranged from 30 to 40 inches in thickness. The coal that is mined in Grant Township is No. 3 coal, and extends to the Linton field. This vein in geological formation is above No. 2.

The character of the county is considerably changed and is quite different west of the irregular line, traced across the county from north to south, at the western limit of the millstone grit, not only in surface features, but in soil and in the geological formation as well.

We now come to the great coal fields of the county, which are in Stockton and Wright Townships. This has been one of the most productive in the state. Most of the coal mined in this district has been a No. 4 coal. Southeast of the city of Linton,

several hundred acres of No. 4 coal have been mined by the process of stripping. A powerful steam shovel removes the overlying mantle rock, averaging 30 feet in thickness, which consists of clay shale, flaging stones and drift. A second steam shovel and much smaller than the first, moves along on the surface of the coal and loads the coal in small cars after it had been loosened by charges of dynamite. Southeast of Jasonville, in Wright Townhsip, there is another large section being mined by stripping. This is also a coal No. 4. The coal at this place would average 30 feet below the surface of the ground. This coal was in a bed, 4 feet thick, but the covering over the coal was too weak to mine in any other way. The material over the coal consisted of 7 feet of shale, above this, 5 feet of sandstone which readily broke up into fragments and was removed by the steam shovel. The sandstone was not continuous. Above this was other sandstones in thin layer, and above this, several feet of clay, which included a great deal of gravel, quartz pebbles, and small granite boulders.

Northwest of Linton, a third stripping machine was in operation, and there another large section had been worked over. There was first above the coal, a slate of a few feet in thickness. This slate changed to a shale at several places. This slate contained many pyrite boulders. Above this shale and slate was a limestone, 4 to 6 feet in thickness. Above this was a mantle of clay and drift, 10 to 20 feet in thickness. This drift contained granite pebbles of many colors. One very good specimen of chain coral, *Halysites catemulata*, was observed. This drift contained many granite boulders of good size. When a stripping machine is used the ground is left in a very uneven condition and not fit for farming, though the material thus dug up in many places contained shales and clays that would make a good brick. The coal taken at this place was No. 5. West of Linton, and near the county line, is a small area of No. 6 coal. At this place the coal No. 6 is at a depth of 50 feet; No. 5 coal is reached at a depth of 115 feet; and No. 4, at a depth of 175 feet. Mr. Lew F. Akre, of Linton, who has been a coal prospector and driller in this field for several years, kindly gave me the use of his record books in which he has carefull recorded the results of a large number of wells covering the whole field. In looking over these valuable and reliable records, it was observed that the rock formation of the western part of the county tips to the west, or a little south of west, about 50 feet to the mile. The eastern part of the county,

in its formation, is also inclined to the west, but the incline is not so great as in the western part of the county.

The Summit mine, two miles west of Linten, shows the following record:

Surface, 18 feet clay, drift.
Blue shale, 46 feet.
Black shale, 1½ feet.
Black chip slate, 2½ feet.
No. 4 coal rider vein, 1 foot, 9 inches.
Fire clay, 2 feet.
Dark sand shale, 4 feet.
Sand rock, 14 feet 9 inches.
Gray shale, 15 feet 9 inches.
Coal No. 4, 5 feet 9 inches.
Dark sand shale, 24½ feet.
Black shale, 9 feet.
Coal No. 3, rider vein, 1 foot 2 inches.
Dark shale, 4 feet 4 inches.
Coal No. 3, 1 foot 10 inches.
Light shale, 6 inches.
Limestone, 1 foot.
Dark shale, 1 foot 9 inches.
Coal, 11 inches.
Gray shale, 3 feet.
Coal, 9 inches.
Fire clay, 7 feet 9 inches.
Sand rock, 5 feet.
Gray shale, 11 feet.
The total is about 186 feet.

The following is the record of the Sponsler mine, about three miles southeast of Linton:

Surface, 9 feet.
Yellow soft sand rock, 11 feet.
Gray shale, 15 feet.
Coal No. 4, 5 feet 6 inches.
Gray shale, 8 feet 6 inches.
Limestone, 1 foot 6 inches.
Gray shale, 15 feet.
Black shale, 8 feet 6 inches.
Coal No. 3, 10 inches, (rider vein.)
Fire clay, 2 feet 2 inches.
Gray shale, 6 feet 3 inches.
Coal No. 3, 10 inches.
Gray shale, 4 inches.
Sulphur rock, 10 inches.
Gray shale, 7 feet 3 inches.
Dark shale, 2 feet 9 inches.

Brown limestone and sulphur, 1 foot 7 inches.
Dark shale, 10 inches.
Coal No. 3, 1 foot 4 inches.
Dark fire clay, 2 feet.
The total depth is 101 feet.

It will be noticed that No. 3 coal splits up so that there is no workable vein. No. 3 coal has been mined in the Linton field at a few places and is the lowest coal mined in that field.

The following is the record for a hole drilled, three miles northwest of Linton, near the Atlas store for the Summit Coal Co.:

Surface, 12 feet.
Black shale, 9 feet.
Blue shale, 35 feet.
Sand rock, 12 feet.
Blue shale, 35 feet.
Dark shale, 1 foot.
Black limestone, 1 foot 6 inches.
Black chip slate, 2 feet 8 inches.
Coal No. 4, rider vein, 1 foot 7 inches.
Fire clay, 2 feet 3 inches.
Light sand shale, 10 feet.
Sand rock, 15 feet.
Gray shale, 14 feet.
Coal No. 4, 5 feet.
Dark sand shale, 1 foot.
Dark sand rock, 14 feet.
Dark gray shale, 9 feet.
Dark chip slate, 7 inches.
Coal No. 3, rider vein, 1 foot 4 inches.
White fire clay, 6 feet 4 inches.
Sand rock, 2 feet 6 inches.
Dark gray shale, 4 feet 6 inches.
Coal No. 3, 1 foot 2 inches.
Sand rock, 1 foot 6 inches.
Gray shale, 2 feet 8 inches.
Coal No. 3, 4 feet.
Dark gray shale, 1 foot.
The total depth is 212 feet.

It will be observed here that the No. 3 coal is split up.

PETROLEUM.

Eighteen wells have been put down in Washington Township by prospectors for oil. All of these holes have been drilled to a depth of 1,750 to 1,800 feet, including several feet in Trenton limestone. What is known as "oil sand" has been found in most

of them, but the result has been in most cases "dry holes." Four of these wells, however, are producing daily, a total of 10 to 12 barrels of a very high grade oil. One of the number is a gas well. The well was not what was hoped for, and the casing was pulled. From the hole has flowed, for eight years, quite a stream of salt water and excaping from this hole, along with the salt water, is the gas. This gas, separating at once from the water, has been burning almost continually for all these years. A flame from 10 to 15 feet high is produced by the escaping gas. Several attempts have been made to plug the hole, but without effect. Four other wells have been put down in other parts of the county, but have disappointed the projectors. In the well put down in Taylor Township, the Trenton rock was reached at a depth of 1,487 feet and showing oil at 1,567 feet, and the well abandoned at a depth of 1,642 feet. The rock formation, the Trenton limestone, in these wells is shown to incline strongly to the west.

Drainage.

The tributaries of White River, in the eastern part of the county, are Jack's creek, and Goose creek which drain Highland Township. Richland Creek is the main tributary in the east part of the county. This stream enters the county in the northeast corner of Beech Creek Township, and leaving this township at the southwest corner, crossing Richland Township to the southwest corner, where it empties into White River. Plummer Creek, a branch of Richland Creek, drains the southern part of the county. Doan's Creek and Indian Creek, in the southeastern corner of the county, drains a few square miles of that section into the east fork of White River.

Ninety-five per cent of the eastern part of the county is drained into White River. On the west side of the county the main stream is Eel River, which enters White River, 3 miles south of the north line of the county. Ninety-five per cent of the western part of the county is drained, eastward and westward, into White River, through state ditches. In the northwest corner of the county the drainage is out of the county to the west. On account of the ruggedness of the land, east of White River, the water runs rapidly to the main streams.

White River takes an angular course across the county, winding its way through a valley about 36 miles long. It has a slight fall, taking the elevations furnished by the government for Worth-

ington and Elliston, most of the fall is at one place, which is at "Rock Ripple," a point 3 miles south of Worthington. Here the water has a fall of nearly 2 feet in a distance of 300 feet, and when the river is low there is only one point where you can cross the "ripple" with a row boat.

There is an evidence of quite a different drainage in a former geological age. Eel River probably emptied into White River at the point where Latta's Creek now flows into White River. There is a well defined river valley from Worthington to that point. In fact, when the water now becomes high in Eel River, the overflow reaches White River at that point. This valley is an alluvial deposit, 100 feet deep at Worthington, as was shown by the drillings for a water supply for that city. Between Elliston and a point, one and a half miles west of Switz City is a ridge of land or divide. This divide separated the water that flows to Latta's Creek ditch, or the Eel River of a former age from the waters south of this ridge which forms the headwaters of the Four Mile Marsh, Beehunter Marsh, and the Goosepond. There were former large areas of wet land, several miles in length and width. These have all been drained and now form some of the best land in the county. These three marshes are also alluvial deposits and range from 60 to 100 feet deep. In Washington Township, when the wells were put down in search of oil, the character of these alluvial deposits and depths were shown. They have for their valley sides all the characteristics of old river beds. The lower deposits of these old valleys consists of sands, clays, and coarse gravel. The Linton water works are at the head of the Beehunter valley. The several wells put down at this point show an abundance of sand and granite pebbles of all sizes, shape, texture, and color, up to 2 or 3 inches in diameter. A large section of the southwestern part of the county is made up of this alluvial deposit, and one of the most interesting things regarding this alluvial deposits, is that the bottom of these valleys is much lower than the present bed of White River, to which the surface from these alluvial valley lands flow.

At Worthington, Eel River, no doubt, during the glacial epoch changed its course. The valley sides between the two rivers becoming narrow, Eel River broke through this side wall and by an abrupt change, joined White River at a new place, 8 miles higher up in its course. The slope of the valley sides in this vicinity, as determined by the sandstone bluffs, indicate very plainly that Eel River has changed her course and probably

during the glacial period. At the junction there is a gravel bed, the extent of which was not known until developed by Mr. Z. P. East, of Worthington, after 10 years of continued and persistent effort. The task was started in 1906 by cabel and clam shell bucket. The bucket dipped the gravel from the bed of the river and the load was then carried by trolley to cars. This process was found to be too slow and unsatisfactory, then a powerful pump was installed. It was then discovered that the river itself was in the way. At this place, White River winds in a strong S curve, but with the curves reversed. Mr. East then planned to change the channel of White River. The river flowed in a curve one and fourteen-hundredths of a mile long. By cutting across to both ends of the curves a new channel was made 2,200 feet long. In cutting this channel, it was discovered that the soils overlying the gravel had a depth of only 10 feet. It was also discovered, that in cutting this new channel, that there was a line of very tough silt lying across the proposed channel. This bed of silt was about 300 feet wide and exceedingly difficult to remove. It seemed to be an ancient bed of Eel River, following closely the ice age. This old bed, if such it be, is fully one-half of a mile ahead of where Eel River now flows into White River, the point of junction since the glacial epoch. The material in this old bed was so compact that it could be removed only by blasting. Between the old bed and the new cut off there is probably 80 to 100 acres of gravel. The gravel is known to be 50 feet deep, though it is being used at the present time only to a depth of 20 feet. The problem of securing machinery that will take the gravel from this greater depth is being considered. At present, a "10" centrifugal pump and flat gravity screens are used, thus leaving the gravel practically clean. Five to eighteen cars a day of 30 cubic yards capacity are being loaded with this gravel. The material is held in high favor by the Pennsylvania R. R. people, both for ballast and concrete purposes. This gravel is also popular with the road men for ballast. The gravel shows the action of water and ice, and is no doubt a deposit of the ice age, in conjunction with the force of the two rivers at this point, checking the further drifting of this material and causing it to accumulate here. No other bed of gravel has been discovered in the county, beneath any of the alluvial deposits, of any economic value.

Glacial Epoch.

Evidence of the glacial epoch is to be seen at many places in

the county, especially in the western part. During the glacial epoch, there was strewn everywhere over the northern part of North America, fragmentary material of past geological ages. The continent must have been much higher than it is now. Intense cold must have prevailed. Ice sheets, such as exist in Greenland today, must have been formed. This great mass of ice, slowly moving southward, pushed with it the debris of former periods. This material moved by the ice is known as drift. It is made up of a mixture of clay, sand, gravel, and stones of all sizes, a mixture of dissimilar elements, unsorted and unstratified. This drift reached this far south. Granite pebbles and boulders, of various sizes are to be observed at several places. The sand and gravel, beneath the alluvial deposits everywhere in the county, must be considered a part of the dirft. In the several hundred acres of land stripped for coal the glacial drift formed a large per cent of the material moved. Granite boulders of various texture and color, up to 2 feet in diameter, were noted at one point in Wright Township. A plentiful supply of clay mixed with pebbles, formed the basis of some of the ground stripped for coal. The drift is 10 to 20 feet deep over much of the extreme western part of the county. In the small streams at several places in Wright and Stockton Townships, granite boulders were observed. In some drift in Grant Township, a granite boulder, 2 feet in diameter, was noticed.

The ice sheet probably entered what is now Greene County from the north and west of White River, pushing its way to the south and filling in all the valleys of a former geological age with sands, clays, and gravels. These have since received rich alluvial deposits, making the fine farming country along the ancient valley of Eel River, and the large district in the southwestern part of the county. A microscopical examination of wood, taken from two wells at a depth of 60 and 100 feet respectively, in two of these valleys, shows that it is related to the pines and of an epoch long past.

East of White River, the evidence of a glacial drift is less certain, though it is present in a few places. There is one small terminal moraine on Sec. 25, in Highland Township. This sand and gravel bank is being used for road dressing.

Fire Clay.

The constant attendant of a coal seam is a thin seam of fire clay. The thickness of the seam of fire clay may vary and does

vary. At numerous places examined this fire clay strata was less than one inch, and sometimes only enough clay to show its presence. There is an area of this material underlying the corporation of Lyons, and extending north into Grant Township, one and one-half miles, and south of Lyons, more than a mile and comprising in all, a district of at least 4 square miles. It is a fire clay of considerable value.

Well No. 2 was put down in the school yard in Lyons, in1912. There was a clay drift of 15 feet deep. Passing through this, a seam of black slate was encountered, which had a thickness of 14 feet. Under this was a seam of coal 3 feet, 2 inches in thickness and below this, a strata of fire clay, 4 feet, 10 inches in thickness. In a well, put down in the yard of the M. E. church parsonage in Lyons, in 1915, the same order of stratifications was encountered, but the fire clay here was found to be 7 feet in thickness. In another well, put down not far away, this clay was found to have a thickness of 12 feet. Everywhere in this field where wells have been put down, this fire clay has been found to be of good thickness, and at no great distance from the surface of the ground. In the southern part of this field, the clay is white. In the northern part, it has become a variegated yellow.

Samples of this clay have been sent to several places where it has been made into various articles. In each test the clay has been considered of the best quality. Samples were sent to Karls Bad, Austria, to be tested and was also pronounced a high grade material. It would seem from the several tests of this clay that have been made, that there is a fine opportunity here to develop a large industry.

A fire clay was found on the Hay's farm, near Worthington, in 1906, which proved to be excellent material for modeling. This clay has since been used with success, for this purpose in the schools there. The articles, when placed in a kiln, take on a fine finish.

ARCHAEOLOGY.

In considering this topic, only that phase of the subject will be considered, which relates to prehistoric man and some of the evidence of his existence. The Worthington mounds, which have been nearly all destroyed, covered the largest area of any in the county. The building of the railroads and business houses made it necessary to level them. There was a mound where the Exchange Bank now stands. This mound extended north some

300 feet and east of this point to the present site of the Stock Yards and north again to the I. and V. station. These mounds were about 9 feet in height as measured by Prof. John Collet, State Geologist, and published in his report in 1880. Prof. Collet estimated that 4,000 cubic yards of earth were necessary to make these mounds. There were three places on this mound which marked the vertices of the triangular shape, which made it appear as three mounds. This mound, at one point, contained a burial vault "8 feet long, 5 feet wide, and 3 feet deep, surrounded by a *sand stonewall*, 18 inches thick."

In 1878, the town authorities of Worthington found it necessary to remove a portion of the north side of this mound in order to make some improvements. In doing so, a few Indian graves were exposed. In completing the Indianapolis and Vincennes railroad in 1880, some more of the mound was removed to fill in the old Wabash and Erie Canal, along the track. In this case the interior of the mound was reached. Here was found a bed of ashes, some 10 or 12 feet square. Bones of various animals were observed and fragments of pottery, along with mussel and snail shells. The remains or fragments of quite a number of skeletons were found in a great circle about this ancient fire place. In this mound have been found various household implements, vases, images, also flints, flint knives, and one copper axe. This copper axe, on analysis, was found to contain copper, with a little iron and carbon showing its origin from the copper mines of the Lake Superior region. In 1898, other improvements were made near the railway station, and a further destruction of the mound followed. Among the several trinkets and articles dug up were two images. One of these images is at the present time owned by Dr. J. D. English, of Worthington. The image was probably 4 inches long when entire, now the lower portion is broken away. The image is that of a woman, the features are clear cut and well defined. The hair is in a roll on each side of the head, and fastened at the back of the head with cleverness and skill. The curves are symmetrical and artistic and, in all, it represents a piece of workmanship of high order. Dr. William H. Holmes, Head Curater of the National Museum at Washington, D. C., in a letter to Dr. English, of March 30, 1898, regards the image as one that had been made by the mound builders. The other image discovered at this time was about 8 inches in length, and is now in the State Museum. In one instance, the skull of a skeleton had the face covered with a piece of mica, and for what purpose can only be

conjectured. A few of the relics found are still in the possession of people at Worthington, but most of them have been scattered and some lost. Each county in the state should have at the county seat a museum, where the relics of prehistoric man and other objects of interest, might be kept for the benefit of future generations. About all that is left of the Worthington Mounds is a portion now occupied by the stock yards pens, and a portion of the bank along the right of way of the Indianapolis and Vincennes R. R. joining the stock yards. A quarter of a mile north of Worthington, near the right of way of the Terre Haute and Evansville railroad is another mound. This one is 50 feet in diameter and 8 feet high. The field has been in cultivation for several years and plowing has reduced the mound to its present height. One arrow point and several small pieces of flint were picked up on this mound on the day of visit, August, 1915.

Three and one-half miles south of Worthington, in Sec. 8, in Fairplay Township, stands the largest mound in the county. This mound is in a field near the roadside. The last visit there was in August, 1915. Mr. Daniel W. Solliday of Worthington, and an old citizen of the county visited this mound for the first time in 1870, and says that the mound and surrounding ground was at that time covered with a forest of black oak, that this timber was seen after cut away, converting the spot into farm lands. With his assistance, the mound was measured on this occasion. Though probably reduced much from its former height by plowing and working, the mound still has a height of 30 feet and a base diameter of 145 feet. The mound at this time was covered with standing corn and a fresh rain had cut gullies down between the rows of corn, exposing at different places, several fragments of human bones. Several human teeth and one flint arrow point were found. The mound has never been opened, though two or three persons, without permission, attempted it a few years ago. After finding some pottery, which by unskilled work was broken, they were compelled to replace the earth removed and close the mound. This mound stands so near two public highways and one railway that had it been left in its original condition, the timber not cut away, it would have been an object at the present, time, of the greatest interest and a witness of a wonderful people of the prehistoric past.

There are still to be seen in the county a few mounds, such as those across the White River, in Highland Township, and a few in Washington Township, near White River. In Washington

Township, in the spring of 1910, while digging a peat hole, a skeleton was found 2 feet below the surface. Along with the bones was a beautifully colored vase, which contained 6 long flint arrow points. The young man, digging the post hole was not aware of the obstruction until the vase was in fragments. The "find" was brought to me for examination. The vase was of the workmanship represented by the Indians, usually known as the mound builders, though there was no evidence of any mound at the place where the vase was discovered. The arrow points were unusually long, of the same size, form, texture, symmetry, and represented the highest skill in this art. They were all of the same color of flint.

There are a few good private collections of Indian relics in the county which are made up largely of flint arrow points, fleshers, axes, along with a few ornaments and articles of slate. In my own collection, consisting largely of arrow points of more than 300 in number, and all picked up on one farm in northern Indiana, these differences are noticeable. Those in the northern part of the state may be readily separated into five styles of manufacture, while those in this section fall into a smaller number of groups. Those in the northern part of the state are smaller size and average less in length. Those in this section seem to be made of a flint of different and better quality than those in the northern part. There are other differences, better seen than described.

Natural Wonders.

There are a few natural wonders in the county, among which may be mentioned the big tree near Worthington. This tree is a large sycamore and has been pronounced the largest tree in the state. Competent authorities have also said that this tree is the largest shade tree in the United States. Descriptions and pictures have appeared in a number of publications in the state. It is truly a mammouth tree.

On the bluff bank of White River, one and one-half miles northeast of Worthington, in Sec. 15, in Jefferson Township, and near the Indianapolis and Vincennes railroad track, is what is known as the "Tea-table." This sand stonerock, somewhat in the form of a table, and about 12 feet square, crowns the bluff bank of White River at a height of nearly 100 feet. All the rest of the rock, which has at sometime surrounded this huge remnant, has worn away. By a little effort you may reach the top of this

rock from the west side. Here, you may view the country for a great distance. This rock bears many names. Some of them have been cut there by persons who have gone to their reward more than three-quarters of a century ago. This old sandstone table has been a witness to more than one geloogical age. Could this "table" speak it could tell us how long it took White River to make her valley, and how long ago it was when the ice sheet of the north pushed her cold fingers down into the valley, and when she withdrew them. It could tell us when the Indians came and first stood on this table and watched the rising sun and then saw it go down in the splendor and beauty of a western sky. This table is an interesting and notable place and attracts many visitors.

The caves, Ray's and Ooley's have been mentioned. Another natural feature of considerable interest is what is known as "Lost Creek," in Center Township. Here a small creek sinks into the ground and does not appear again for more than two miles.

Soil.

Soil, from the standpoint of the farmer or gardener, is good or bad, according to what it will produce in the way of grasses, grains, or vegetables. Soil may also be considered in a casual way as sand or clay, according to the amount of sand or clay present. Soil, in general terms, may also be alluvial drift or vegetable. But the soil means more than these terms or definitions might imply. It is that thin covering of the land surface to be observed everywhere. This covering has been a very long time in the making, when mother earth pushed her children, the great rock surfaces, from the sea, the atmospheric agencies at once set to work to disintregrate the rock and to form soil. When there was soil enough, plants began to grow. The plants then added their energy to the task of rock destruction in the way of humic and humus acids. One geological age succeeded another, but the work of making soil went on. Not all the soil we have here was formed here, neither do we have here all that was made here. Some has been carried away, some has been brought to us from elsewhere, but what there is here is the most valuable asset we have.

There are very few places where the soil is where it was formed, in situ, and still resting upon the parent rock. All the rest has been shifted by wind, water, and gravity to some other point

than that of its formation. All that party of the county, west of White River, is more or less covered by drift. East of White River, for some distance, glacial effects may be observed but they are slight. In the eastern part of the county, where the country is much broken, all the valleys are narrow, but they contain a rich sandy loam and are very productive, while all the upland or stony land, which comprises quite an area is of little agricultural value. The covering is not deep, thinning out and exposing the rock mass. The poorest land of the eastern part of the county, in most cases, is still occupied by forests. About Worthington the soil is sandy loam. A mile and one-half northwest of Worthington there is another small area of sandy soil. A mile and a half northeast of Worthington, in Highland Township, is another area of this soil, and north and west of Bloomfield there is another district of this soil. All of these soils are generally used each year for growing melons and for this purpose are the finest of grounds, and large crops are harvested. There are a few places in the eastern part of the county where the soil contains some gravel. West of White River, from Worthington to Switz City, there is a valley of alluvial deposit in which there is considerable sand, making it a sandy loam. This loam also forms a large tract in Washington and Stafford Townships. Along White River, throughout its course across the county, there is a flood plain of alluvial deposit. This is a silt loam. The water some seasons causes a loss of crops, but the whole flood plain is wonderfully productive land and despite the occasional loss by high water, the land commands the highest prices. All this valley land is given over mostly to the growing of corn, year after year.

The Four Mile marsh in Washington and Fairplay Townships, the Beehunter marsh, and the Goosepond in Washington, Grant, and Stafford Townships presents other types of sand and silt loams. Their areas were formerly large marshes covered with brush and overflowed with water each season, have now all been drained and are under cultivation. These lands now produce large yields of corn. Peat soils are found at a few places, perhaps the largest area of this soil is to be found in the Beehunter marsh, where there is perhaps a thousand acres. There is another large area along Latta's Creek, in Grant Township, and small area on Sec. 12, Washington Township. This muck soil is not a pronounced type of its kind. There is a considerable mixture of other materials.

The most extensive soil type in the county is the yellow clay,

or Miami silt loam. It is a heavy soil. It makes up the large part of farm lands of the county east of White River, and also of the northwestern part of the county. This soil may vary some in color, but it is the same basic material. It is this soil that presents problems of diversified farming. Wheat, oats, corn, clover, timothy, and some alfalfa and cowpeas are grown. Rotation in crops is practiced. All of this clay soil requires careful handling. Plowing, when too wet, solidifies and makes difficult to keep free from clods. It requires much tile draining, not so much to carry away the surplus water as to make the ground porous and admit the air. The humus of the soil is not abundant and commercial fertilizers must be applied to insure better crop yields. In the eastern part of the county there are places where the fields are "worn out" and have been abandoned and are now covered with growth of sassafras and persimmon brush. Occasionally, a field in this condition, may be seen in the western part of the county.

While there is much land in the eastern part of the county that is broken, poor, stony and of low value, it is all good for something. There are a few fine orchards in this section that are proving to be of considerable commercial value. As excellent a quality of fruit as is to be seen in the markets anywhere is grown.

This part of the county can be made one of the finest of fruit lands.

Iron Ore.

At the junction of the sandstone and limestone, an ore branch of Plummer Creek, also at the junction of the same rock along Richland Creek, there is a limestone ore of which 40 per cent is a good iron. This iron bearing rock is from 6 to 10 feet in thickness and at some places more than this. Seventy-five years ago, a furnace was built and the smelting of this iron began. This work continued for 15 years and more than 100 men had steady employment.

There is still an abundance of iron in this locality and no doubt, the day will come when this grade of ore will again be profitable to work and the smelting resumed.

Brick.

When the Indianapolis and Southern railway was constructed across the county, a large cut was made for the road bed just outside the corporation of Bloomfield. This cut revealed the

presence of a large bed of shales and clays, suitable for making brick. A plant was built and a high grade of brick is manufactured. The plant now does a large business and carloads of this building material are sent to various sections of the country.

Greene county has a varied list of natural resources and interests and a number of them await development

OFFICE OF STATE SUPERVISOR OF NATURAL GAS.
INDIANAPOLIS, IND., December 31, 1915.

Hon. Edward Barrett, State Geologist,
Indianapolis, Ind.

Dear Sir:

I am sending you today the manuscript of the Annual Report for the 39th Annual Report of the Department of Geology.

Thanking you for the valuable suggestions and assistance I have received from you, I am,

Very truly yours,

FLOYD E. WRIGHT,
State Supervisor of Natural Gas.

Oil and Gas.

By FLOYD E. WRIGHT, Supervisor Natural Gas.

In the old gas field in Indiana, covering parts of Tipton, Hamilton, Marion, Hancock, Shelby, Rush, Fayette, Henry, Wayne, Randolph, Madison, Delaware, Jay, Blackford, Wells, Huntington, and Adams Counties, where all farm houses and residences in the cities which grew in a few months, from small towns to large cities, supported by factories of different kinds, used gas as their fuel, there only remains some of the small towns and farmers using Indiana gas today. Some of the towns yet using Indiana gas are Oaklandon, McCordsville, Fortville, Pendleton, Lapel, Middletown, Windfall, Rushville, Arlington, Greenfield, Knightstown, Carthage, Milroy, St. Paul, Shirley, and Shelbyville. While the above towns are using Indiana natural gas, it is only used for lighting and cooking, as there is not sufficient quantity to be used for heating purposes.

Muncie, Anderson, Elwood, Alexandria, Fairmount, Hartford City, Marion, New Castle, Richmond, Noblesville, Tipton, Lynn, and Middletown are now being supplied with West Virginia gas, which is piped into the old mains once used to distribute Indiana gas. Some of the above towns made an abnormal growth during the gas boom period, in which hundreds of factories of different kinds, were erected in the various towns on the belief that natural gas was something coming from the inside of the earth, that was being generated as fast as it was liberated through the thousands of wells, and that it would last for all time to come. Many fortunes were lost by those who acted too strongly on the above erroneous ideas. The gas instead of being inexhaustible was limited in quantity, and came from crude oil, the origin of which was the distillation of the millions of small sea animals that were deposited at the same time the oil bearing rock was being formed in the bottom of the sea.

The Oakland City oil field produces enough gas to supply Winslow and Oakland City, as well as furnish power in the field for pumping.

Sullivan, for about 10 years, has been supplied by gas from Jamison oil pool, about two and one-half miles west of Sullivan. The supply of gas in this field has been more or less limited, as it is more an oil field, than a gas field. A good gas well has been recently drilled on the Springer farm (Sec. 12, Gill Township), by E. R. Riggs, which shows a volume of 1,300,000 cubic feet per twenty-four hours. The well has been connected to the mains supplying Sullivan. This well is some distance from any gas or oil production in Sullivan County, and promises to be the opening of a new pool for Sullivan County.

The pressure of the gas wells still producing in Indiana, is 71.5 pounds, which is a small decrease from the preceding year, due to a well giving out in the Oakland City field that was drilled during the year of 1914, and showed a pressure of 590 pounds, but had a small volume, and was soon reduced to nothing, as it furnished gas for the town of Oakland City and a part of the Oakland City oil field for a while.

The Indiana portion of the Lima-Indiana field in the year 1915, produced *363,708* barrels of oil from *3,124* wells. In addition to the natural decrease in the wells a great many of the small producers were pulled and plugged during the year, which accounts for the falling off of the production from what it was in 1914.

The production of the Sullivan County oil field for 1915, is a little short of what it was for 1914, on account of the price of crude oil going down to 78 cents and remaining there for a long time, during which period the operators practically stopped drilling any new wells pending an advance in prices. Since there is a natural decrease in the production of a well, the production of the field will suffer unless new wells are brought in fast enough to equal the natural falling off of the old ones. The production from 503 wells for the year was 547,500 barrels. During the early part of the year, two good gas wells were brought in by James Crawford, 6 miles southeast of Sullivan. The wells are some distance from any other production in the county and promise to be a lead to a new pool.

The Sullivan County oil field has proven the old theory, that a dome or anticline is necessary in the underlying formations before oil can be found, is not exactly correct, since in the main pools of the county the dip is only in one direction, the other being as nearly level as possible. In other words, the oil bearing stratum, if traced, will be found to run level for some distance

and will suddenly take a sharp dip to the west, as west is the direction of the general dip. Gas usually is found at, or near the point where the rock starts to dip, and the best oil wells will be found on down the slope; consequently, the oil cannot be said to be produced from a dome or anticline, since the territory containing the pool of oil does not have the necessary dip in all directions, from one point, to make it a dome or anticline.

The Oakland City, Princeton, and Petersburg oil fields combined, produced 136,570 barrels from 266 wells for the year. The Petersburg pool is about 4 miles west of Petersburg and is a new pool for Pike County. The Emory Oil Company, following the theory that gas comes from oil, drilled some wells near an old gas well, which was drilled a few years ago and now have several wells making from 50 to 75 barrels daily.

The total production for the state for the year was *1,047,778* barrels from *3,983* wells.

The total number of wells abandoned for the year was 877.

During the year, the Lynn Oil and Gas Company drilled three oil wells in Sections 8 and 17, in Township 2, North and Range 5, West in Daviess County, which is about four and one-half miles south of Cannelburg. A gas well drilled on the Griffin farm in the same section by J. W. Vincent, about three years ago, to a depth of 380 feet, led to the belief that an anticline existed in that vicinity and as a result the Lynn Oil and Gas Company drilled, up to date, three wells to a depth of about 725 feet, which promised to be about 40 barrel wells, and the vicinity promises to develop into a very good oil field.

The formations existing near the surface are the coal measures and the oil sand, which is about 30 feet thick, belongs to the Huron group of sandstones and shales, and is no doubt, the same sands as those which have produced gas and some oil at Loogootee for several years. Three dry holes were drilled about one and one-half miles east of the above mentioned wells, by E. R. Riggs of Sullivan, which indicates that the field will not have much eastern extent, but probably will extend to the west and southwest.

The Ohio Oil Company drilled a well on the farm of E. E. Stiles in Sec. 31, Taylor Township, Greene County, to a depth of 1,567 feet, with a smell of gas at 610 feet and a small showing of oil at the bottom of the hole. The following is a log of the above well:

LOG OF No. 1 WELL E. STILES FARM, SECTION 31, TAYLOR TOWNSHIP, GREEN COUNTY, INDIANA.

Surface to 15 feet, soil drift and mud.
15 to 20 feet.....Quick sand, 5 feet.
20 to 40 feet.....Soft mud, 20 feet.
40 to 45 feet.....Lime shell, 5 feet.
45 to 72 feet.....Shale and water, 27 feet.
72 to 80 feet.....Lime shell, 8 feet.
80 to 100 feet.....Shale and water, 20 feet.
100 to 120 feet.....Lime, 20 feet.
120 to 125 feet.....Broken shale, 5 feet.
125 to 250 feet.....Lime stone full of water, 125 feet.
250 to 300 feet.....Soft black mud, 50 feet.
300 to 310 feet.....Lime shell, 10 feet.
310 to 610 feet.....Hard lime stone, 300 feet.
610 to 615 feet.....Soft lime, 5 feet.
At 610 feet lime got soft and brown, with a smell of gas, and you could just notice a rainbow of a color of oil.
615 to 710 feet.....Brown lime stone, 95 feet.
710 to 800 feet.....Brown lime full of water, 90 feet.
800 to 1,250 feet.....Black shale, 450 feet.
1,250 to 1,285 feet.....Lime shell, 35 feet.
1,285 to 1,290 feet.....Very hard lime, 5 feet.
1,290 to 1,400 feet.....Dark shale, 110 feet.
1,400 to 1.487 feet.....Brown shale, 87 feet.
1,487 to 1,642 feet.....Niagara rock, 155 feet.
At 1,567 feet rock got soft and for ten feet we had a brown lime with a show of oil not enough to get any pure oil, but really more than you would call a rainbow.
Total depth of well, 1,642 feet.
Drilling commenced, September 8th, 1915.
Drilling was completed, November 11th, 1915.
Pipe used in well was, 12½ inch casing, 80 feet; 10 inch casing, 531 2-12 feet; 8¼ inch casing, 885 feet and 6¼ inch casing, 1,584 feet.

Contractor, IRA C. HUFF.

The Bedford Oil and Gas Company in 1913, drilled an oil well one and one-half miles west of Heltonville to a depth of 1,750 feet, at 1,680 feet they struck oil in Trenton rock which was estimated to be a 15 barrel well. The same company drilled another well, 1,100 feet deep near the first well, in which they struck a good flow of gas at 1,090 feet. The formation immediately underlying the surface in this vicinity is the Knobstone shale, it appears to be in the form of a dome or anticline in this vicinity, with the crest a short distance west of Heltonville. The Knobstone shale area in this vicinity is surrounded by the Bedford and Harrodsburg

limestones, which is unusual, since the Knobstone shale is a lower geological formation than the limestones and would regularly be found to the west of them, but in this vicinity, portions of the Bedford and Harrodsburg limestones are found east of the Knobstone shale out-croppings, all of which indicate that the underlying formations are high and are in the right position to produce oil or gas.

A local company at Bainbridge drilled a well on the Miller farm, one and one-half miles west of Bainbridge to a depth of 1,647 feet, at 1,450 feet they got a good showing of oil, the rock producing the oil was the Jeffersonville limestone.

A dry hole was drilled one mile west of Loogootee in the hope of getting oil along the west edge of the old Logoootee gas field which has been producing for many years. At the east edge of the town of Loogootee, three oil wells are producing about 20 barrels of oil daily, from one of the lower sands of the Huron group. The sand is the same as that which produces the gas west of town and is about 500 feet deep.

The Gilt Edge Oil Company, of Indianapolis, drilled a dry hole near Wilkinson, in Hancock County, which is in the old Trenton rock field of Indiana. Some of the old gas wells in that vicinity have shown some oil, but the quantity is so small that it is not profitable to pump it.

A local company at Veedersburg recently drilled three wells near Veedersburg to a depth of about 1,000 feet. They were dry holes except one, which had a showing of oil at 610 feet.

The E. M. Treat Company, of Pittsburg, Pa., drilled one well at Sargent, P. O., and two at Blankanship, both of which are in the northern part of Martin County. The wells were drilled about 800 feet deep and all had a small showing of oil. The outcropping formation in hills of that vicinity is the Mansfield sandstone, with the sandstones and limestones of the Huron group outcropping in the valleys where erosion has cut through the Mansfield sandstone and exposed the Huron group. Near Sargent P. O. the oil has been seeping out of the rocks where a small stream has cut its way through them. This condition is often mistaken as an indication that oil can be found in the lower formations, the idea is erroneous as nearly all sedimentary deposits contain more or less bituminous matter, and, if found in the form of an anticline, will contain a pool of oil, but on the other hand, if the deposit is penetrated in the syncline nothing will result, except a water well showing that the water pressure is holding the oil in the

top of the anticline. But where an oil bearing sand, lying near the surface has been cut by a stream, there will be as much oil seep out of the rock in the shape of a syncline as there will where it is in the shape of anticline.

There are some good indications of an anticline adjoining and to the southeast of Tunnelton in Lawrence County. The formations near the surface in that vicinity are the Knobstone shale and the Harrodsburg limestone. They have a slight dip in all directions from a point near what is locally known as the Big Tunnel, which is a tunnel on the B. & O. Railroad, southeast of Tunnelton. Trenton rock in this vicinity is about 1700 feet deep and the Jeffersonville limestone, which is an oil-bearing stratum, should be about 1,000 feet deep.

W. R. Dryden, while drilling a water well on his farm near Foultz, struck a good flow of gas at 267 feet deep. The well tested 80 pounds pressure and had a volume of 120,000 cubic feet per twenty-four hours. The gas is produced from the Niagara limestone and is now being used for domestic purposes on the farm. On belief that the gas in the Niagara limestone was an indication of an anticline, some local parties drilled a well 1,000 feet deep in search of oil, but got a dry hole.

The Central Refining Company and the Indian Refining Company drilled three dry holes near Hazleton to a depth of 2,000 feet. The wells were drilled on the belief that the La Salle Anticline of Illinois extended into Indiana at that point. The wells were finished in the Mississippi limestone. The formations penetrated, correlate with the formations in the wells of the Oakland City and Princeton fields. A well was drilled one mile northeast of Linton, on the Lucien Gillett farm, to a depth of 2,085 feet. From 2,046 to 2,060 it produced a small amount of gas and mineral water that overflowed the top of the casing. The gas was not in sufficient quantity to be of any value.

The following is a log of the well from 1,030 feet to the bottom:

1,030 to 1,180 feet	Brown limestone.
1,180 to 1,250 feet	Dark shale with break of limestone.
1,250 to 1,276 feet	Light sand with water.
1,276 to 1,573 feet	Gray shale with streaks of lime.
1,573 to 1,580 feet	Sand with show of gas.
1,580 to 1,835 feet	Gray and dark shale.
1,835 to 1,905 feet	Water sand with breaks of shale and red rock.
1,905 to 2,046 feet	Black shale, very hard.
2,046 to 2,060 feet	Gray limestone, gas with some water.
2,060 to 2,085 feet	Gray limestone with water.

Immediately east of the above well the foundations seem to rise rapidly to the east and to continue to do so for about a mile, when they then dip slightly to the east, having the appearance of a well-defined anticline.

GENERAL INDEX.